E/CONF.39/A/102
10 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A

India

ASSESSMENT AND DEVELOPMENT OF NATURAL RESOURCES IN INDIA

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Assessment and Development of Natural Resources in India.

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Natural resources of a country include all the natural aspects of environment on the surface of the earth, in the ground, in the ocean, and in the air. Land, water, plants and animals are basic natural resources which sustain material culture. The atmosphere, and water in its cycles are inexhaustible natural resources. Land includes soil and minerals. Soil provides the base on which the plants including crops, grasses and forests grow, which in their turn support the animals including man. Water is the essential element without which no life is possible. Natural resources supply food, clothing and shelter; fuel for heating and lighting and power and raw materials for industry.

2. Natural resources are classified under two categories; renewable or perpetual, and non-renewable or fugitive. Soil, water, plants and animals are renewable natural resources. If a sound policy of conservation, development and proper utilisation of renewable natural resources is adopted they give us improved and sustained production of crops, grasses, trees, fish, birds and animals. Minerals are generally non-renewable resources which once extracted from the earth serve only once.

3. The wealth of a nation is the skill and energy of its people plus its proved natural resources. In developing the economy of a country the first step is to locate, measure and evaluate the natural resources and the second step is to plan development of these proved resources. A resource does not officially exist till it is discovered, measured and evaluated. Once discovered and evaluated it becomes part of the capital of the nation. Hence survey and assessment of natural resources, viz. land, water, minerals and energy, are necessary preliminary steps to economic development.

4. Planning in India: The stresses and strains of the Second World War underlined the necessity of a planning organisation for the country, and in 1944 the Government of India established a Department of Planning and Development. At the instance of this Department the Central and State Governments prepared a number of development schemes. The Interim Govt. of India, on the advice of an Advisory Planning Board which reviewed problems of planning, recommended the appointment of a Planning Commission in 1946. The Planning Commission was set up by the Government of India in March 1950, and its primary function was to make an assessment of the material, capital and human resources of the country, including technical personnel and to investigate the possibilities of augmenting such of these resources as are found to be deficient in relation to the nation's requirements and to formulate a plan for the most effective and balanced utilisation of the country's resources.

5. The First Five Year Plan(1951-56) was drawn on the basis of information then available on the land, water, mineral and energy resources of the country. The organisations which deal with the survey and utilisation of natural resources are: the Central Water and Power Commission, the Central Board of Irrigation & Power, the Indian Council of Agricultural Resources, the Geological Survey of India, the Oil and Natural Gas Commission, the Indian Bureau of Mines, the Atomic Energy Commission, the Survey of India, Forest Departments of the Central and State Governments, the Botanical Survey of India, and the Council of Scientific and Industrial Research and its National Laboratories. During the Second Five Year Plan (1956-61) these organisations were greatly expanded and they undertook a series of new surveys and investigations which have resulted in a fuller assessment of the country's natural resources bringing to light the gaps relating to these resources and also deficiencies in relation to the nation's future requirements.

The Committee on Natural Resources

6. When the Draft Outline of the Third Five Year Plan was prepared it was felt that a stage has been reached when as a necessary condition of well-conceived long-term plans, a comprehensive view must be taken of the extent and quality of information available regarding natural resources and the further steps needed in relation to specific long-range objectives concerning the development of irrigation, power, steel, coal, oil and minerals, and land and forest resources, and the conservation of natural resources in general. Need was also felt for an appropriate machinery for planning coordinated studies of natural resources on a continuing basis and reviewing the results obtained from time to time and to identify the the gaps in information. Besides, it was realised that the problem of natural resources is a complicated and inter-related problem in which the various Ministries of the Government of India and State Governments are involved apart from the various sectors of the nation, the farmers, industrialists, the producers and the consumers. There is a host of contradictory interests and claimants for natural resources, and each segment of Government looks at the resources from its own angle. In the best interests of the nation a broad view of natural resources has to be taken so that best use is made of them, reconciling contradictory interests and claims. Further, the problems of resource conservation had also to be kept in view, and it was realised that the present generation is the trustee of the past for the good of the future, and natural resources are a national heritage to be shared with the future generations. This problem was particularly brought into the fore by the shortage of raw materials which was experienced particularly of coking coal, which is required for steel-making and which had been used for less important purposes. It was on these considerations that the Committee on Natural Resources was established within the Planning Commission. The main functions of the Committee are:

i) to assess from time to time the available information regarding the natural resources of the country and to identify gaps in it in relation to programmes of planned development;

ii) to arrange for the formulation, in collaboration with the various organisations concerned, of coordinated programmes for survey of natural resources in different parts of the country in relation to plans for long-term economic development;

iii) to initiate studies on problems relating to natural resources and to make recommendations for their conservation, utilisation and development; and

iv) to disseminate information concerning the country's natural resources through publications.

The Committee was constituted under the chairmanship of the Deputy Chairman, Planning Commission it has representatives of the Oil and Natural Gas Commission, the Council of Scientific and Industrial Research, the Indian Council of Agricultural Research, the Geological Survey of India, the Indian Bureau of Mines, the Survey of Indi , the Central Water & Power Commission, the Meteorological Department, and Director, National Council of Applied Economic Research as its members. The Committee was assisted by four Technical Committees on Land, Water, Minerals and Energy.

Natural Resources of India.

In the following account it is proposed very briefly to deal with the natural resources of India, viz. Land, Water, Minerals and Energy.

I. Land

7. Land, which provides the base for agricultural production, is the most important natural resource of the country. Development of communications, rapid urbanisation and growth of cities, irrigation dams and industrial plants, all make large demands on land. The land surface is fixed, and only a certain proportion is available for cultivation.

Land utilisation

8. The total geographical area of India is about 806 million acres, of which reporting area is about 721 million acres and net area sown is about 318 million acres. The broad features of the present pattern of land utilisation and that anticipated by the end of the Third Plan are set out in the table given below.

Availability per head of cultivable land in India is about 0.82 acres as against 0.42 in U.K., 0.48 in Germany, 0.17 in Japan, 0.50 in China, 2.68 in U.S.A., 2.59 in U.S.S.R. and 50.75 in Canada.

Table 1

Land utilisation in 1965-66.

(Area in million acres)

		1955-56	1960-61	1965-66
1.	Total reporting area.	720.0	721.0	721.0
2.	Forests	125.6	131.0	132.0
3.	Land under miscellaneous tree crops and groves.	13.9	14.0	15.0
4.	Permanent pastures and other grazing lands.	28.4	32.0	32.0
5.	Culturable waste.	54.8	47.0	40.0
6.	Barren and uncultivated land and land put to non-agricultural use.	118.7	114.0	114.0
7.	Fallow lands other than current fallows.	30.9	28.0	26.0
8.	Current fallows.	29.5	28.0	25.5
9.	Net area sown.	318.2	327.0	335.0
10.	Area sown more than once.	44.4	51.5	67.0
11.	Gross area sown.	362.6	378.5	402.0

Soil Surveys

9. In 1955 an all-India soil survey scheme was initiated with a view to carrying out reconnaissance soil surveys leading to correlation of soils of different regions. Three years later the scheme was integrated with the scheme for soil and land use planning drawn by the Central Soil Conservation Board for the catchment areas of river valley projects. By the beginning of 1961, an area of about 18,000 square miles had been covered by both detailed and reconnaissance surveys undertaken through the all-India scheme. Of this area, about 3,000 square miles fall within the catchment areas of the river valley projects. Soil surveys organisations in the States have surveyed about 50,000 squar miles. Under the all-India programme, about 23,000 square miles are to be surveyed during the Third Plan.

Survey of waste-lands.

10. Agricultural production can be stepped up through extension of area under cultivation by cultivating waste-lands, double-cropping of single crop areas, and other measures of intensive farming. There is considerable scope for extending the gross area sown by double-cropping. It is anticipated that the area sown more than once might increase from about 52 million acres in 1960-61 to about 67 million acres by 1965-66. According to t the available land utilisation statistics for 1955-56 the area under culturable waste in 1955-56 amounted to about 55 million acres. In June 1959 the Government of India constituted a Committee to make a survey of land classified as "other cultivated land excluding fallow lands" and fallow lands other than current fallows" and to locate areas where large blocks of land are available for reclamation and resettlemtnt. According to the Committee's findings there are nearly a million acres of waste-land in blocks of 250 acres or more.

II Water Resources

11. Water resources may be divided broadly into surface water and ground water. Their development has to be viewed in relation to the need to increase the productivity of land through irrigation, flood control, drainage and other means, as also to meet domestic and industrial requirements.

(a) Surface Water:

12. The annual rainfall over the entire country represents something more than 3000 million acre-feet of water. Of this, about 1700 million acre-feet is lost due to ev aporation and transpiration etc. and roughly 1350 million acre-feet flow into the river systems. Besides the losses due to evaporation and transpiration, there are losses into the subsoil. These however effect the seasonal distribution rather than the annual runoff, as what goes into the soil as ground water at any time reappears to a large extent as regeneration water ultimately. The entire surface flow cannot be utilised because topography, flow characteristics, climate and soil conditions impose limits on usability. It has been estimated that only 450 million acre-feet can be utilised for purposes of irrigation. Progress in actual utilisation for irrigation is as given in the table on the next page.

Table 2.

Surface water utilisation for irrigation

	Million acre-feet.	as per cent of usable flow.	as per cent of total flow
Up to 1951	76	17	6
Upto 1960-61.	120	27	9
Upto 1965-66 (anticipated)	160	36	12

This indicates large scope for irrigation which still exists, and which is the main hope for increased agricultural production for India's growing millions.

(b) Ground water:

13. Open wells for domestic water supply and irrigation have been in use in this country from ages past. The number of open wells in use was estimated at about 5 million at the beginning of the First Five Year Plan(1951-56). It is expected that this number will increase to over 7 million. The number of tube-wells operating for irrigation purposes was over 3,000 at the beginning of the First Five Year Plan. The average discharge from these wells is 20,000 gallons(imperial) per hour. The number of tube-wells at the end of Second Plan(1960-61) was over 10,000 and it is expected that ultimately this may rise to about 40,000. The area under irrigation from ground water sources was about 15 million acres in 1951 and is expected to be about 35 million acres ultimately.

14. Tube-wells have been successfully constructed primarily in the upper reaches of the Indo-Gangetic valley and in certain coastal deltaic areas. Drillings in some of the lower reaches did not yield sufficient water due to high percentage of clay and fine silt in sub-soil strata. In the extreme northern portion, adjoining the foothills of Himalayas, boulder formation prevented drillings being made without the aid of special equipment. For the Third Plan, a project for 300 exploratory bores is in progress. With a view to facilitating the work of exploration and reducing the need for large scale drilling, it is also proposed to carry out geophysical investigations. In peninsular India such investigations would quickly determine the depth of the bed rock and are likely to give first indications of ground water availability. A survey programme is also in hand in Andhra Pradesh in South India for localising areas of ground water availability, where filter points for extraction of water can be successfully drilled.

(c) Optimum utilisation for agriculture:

15. At the beginning of the Second Plan (1955-56), the area irrigated from all sources was 56.2 million acres distributed as shown below:

Table 3

Sources of water	Irrigated area (1955-56) (Million acres)
Government canals	19.8
Private canals	3.4.
Tanks	10.9
Tubewells and other wells.	16.7
Other sources	5.4
Total ..	56.2

16. The irrigation schemes taken up between 1956 and 1966 are expected to add 13.8 and 20 million acres during the Second and Third Plan periods respectively bringing the total to 90 million acres irrigated areas at the end of the Third Plan. As against this, the ultimate potential of all the irrigation schemes(major, medium and minor) that can be taken up in India is estimated to be about 175 million acres. The net area irrigated by major and medium projects at the end of the Second Plan was about 30 million acres.

(d) Public water supply in urban and rural areas:

17. Modern standards of health and cleanliness demand at least 50 gallons of filtered water per head per day. On this basis, the annual requirement would amount to roughly 7 million gallons or 25 million acre-feet. The real problem with public water supply, however, is disparity in distribution - some locations having surplus water and others having very little.

18. In terms of population, protected water supply facilities were created to cater to 18.0 million urban residents upto 1951. During the First and Second Plan periods facilities to cater to an additional 12.0 million urban residents were created. The Third Plan envisages the establishment of facilities to cover another 10.5 million urban residents. Thus the urban population receiving protected water supply benefits in 1966 would be 40.5 million. This would represent 47 % of the total urban population which is placed at 86.0 million.

19. Future work will include analysis of industrial and domestic effluents, data on extent of pollution caused by them, development of methods for their treatment and preparation of standards to which they should conform, before they can be discharged into rivers.

(e) Navigation and Waterways:

20. India is gifted with several river systems like the Ganga, Brahmaputra, Indus, Tapti, Mahanadi, Godavari, Krishna, Cauvery, Narmada etc. However, water transport today thrives only in a few States like West Bengal, Assam, Andhra Pradesh, Bihar and Kerala. The total mileage of Indian waterways at present in use does not exceed 5000, whereas the potential mileage is very high. The Central Water and Power Commission have prepared a rough outline of a "Master Plan" which envisages linking of the Ganga with West flowing rivers to provide continuous waterways from the West Coast (Arabian Sea) to the East Coast (Bay of Bengal), linking the Narmada with Godavari, linking the Tapti with the Godavari system, linking the Ganga with the Mahanadi, and inland coastal waterway from Calcutta to Mangalore via Cuttack and Madras.

(f) Inland fisheries:

21. Rivers and their tributaries, canals, lakes, reservoirs, tanks and ponds with perennial water supply constitute a rich potential source of inland fisheries. Out of 1.4 million tons of annual catch about 300,000 tons are from inland water. In the First Plan over a million acres of inland waters were surveyed and 68,000 acres reclaimed. In the Second Plan about 300,000 acres of inland waters have been surveyed and an area of 720,000 acres stocked. The Third Plan includes proposals for the development of more than 50,000 acres of water area as demonstration fish farms, 1500 acres for estuarine fish culture and about 1500 acres - 2000 acres of marshy and fallow lands reclaimed for fish culture. An urgent need is a

complete survey of waters which do not dry up during summer and which can be stocked with fish. An inventory of the existing waters as to type, namely, ponds, reservoirs, lakes, rivers, etc. and the areas under each type should be prepared. This should be followed by a detailed inventory of the physical, chemical and biological features. When this work is completed, it will provide a sound basis for development of the inland fisheries resources.

(g) Resources of the Sea:

22. India has a coastline of about 3,530 miles, a continental shelf of more than 10,000 square miles and a large number of gulfs and bays along the coast. This alone indicates the vast potentialities of marine resources in the form of marine algae, fish and other edible animals as well as minerals. Oceans are huge reservoirs of organic material and photo-synthesis occurs in them at greater rate than in forest or grassland. The photo-plankton consisting of diatoms and algae which are responsible for the original photo-synthesis are consumed by the fish and other animals. Properly exploited, the productivity of the sea is expected to be equal to that of land.

(i) Marine algae

Marine algae are commonly used as human food in Japan and China. It is a promising source of food which still remains unexploited in India. Sea-weeds are also the source of agar agar, alginates, mucilages and iodine. Some of them can be used for making jams and jellies etc. for human consumption. Addition of sea-weeds to cattle feeds in other countries has proved remarkably beneficial due to the presence of trace elements which the farm animals generally lack. Similarly, incorporation of sea-weed-cowdung compost to soil proved more beneficial to crops than cowdung alone. A preliminary survey conducted by the Central Marine Fisheries Research Station, Mandapam, indicates that systematic exploitation of sea-weeds would be quite profitable. The need of a comprehensive survey of the availability of economic sea-weeds on India's coastline and their utilisation is urgently indicated.

(ii) Marine fish, molluscs and crustaceans:

Out of the total fish production of 1.4 million tons annually about 1.1. million tons are marine. Of the marine fisheries, the most important are the mackerel, sardines and prawns. In 1955-56 India exported Rs.8.4 crores worth of dried and salted fish. India is one of the first seven fishing nations in the world, Japan being the foremost with an annual catch of about 4.8 million tons. India's need is estimated at about 4 million tons but the production rate is less than a quarter of requirements. The sea fisheries generally exploited are confined to 6-10 miles from the coast.

(iii) Minerals from the sea:

Of the mineral resources in the sea, the most important is the common edible salt. Marine salt industry is well established in the sense that the entire quantity of salt required is produced within the country. In 1956-57, India consumed about 3.11 million tons of salt and exported about 0.25 million tons. Production in 1958 was 4.17 million tons valued at about Rs.8.5 crores.

23. At present only a few hundred tons of potassium chloride are recovered from bitterns against a possible total of about 80-90,000 tons, though requirements of potash (K_2O) for agriculture alone is estimated to be about 80,000 tons per year which is expected to rise to about 2,00,000 tons by the end of the Third Plan. Similarly, bromine is recovered to the extent

of 25-30 tons per year against a possible total of several thousand tons. There is great scope for expanding the sea salt industry if the by-products are recovered and utilised either to support indigenous industries or for export. If present techniques on brines become more efficient then in conjunction with large scale desalting of sea-water, it is quite likely that ocean will become the major source for sodium, chlorine and potassium.

(h) Extent of development, priority etc:

24. The development on priority basis of the water resources is being carried out primarily by the Central Water and Power Commission and the Ministry of Food and Agriculture. The Technical Committee on Water of the Natural Resources Committee has taken up studies on (i) surface water, (ii) ground water, (iii) optimum water use for crops and (iv) use of water for domestic and industrial purposes and (v) control of water pollution, in collaboration with the concerned Ministries. These studies will bring out how and to what extent the above water resources may be more intensively utilised.

III ENERGY RESOURCES

25. The demand for energy in India is growing rapidly due to industrialisation, increasing transport facilities and rising standards of living. India's consumption per head is still among the lowest in the world, as is shown below (Table 4):

Table 4

Country	Per capita energy consumption in tons coal equivalent per annum*
U.S.A.	8.6
U.K.	5.0
West Germany	3.6
Netherlands	2.5
Italy	1.1.
Japan	1.1.
India	0.1

*- Energy from non-commercial sources e.g. wood, peat, dung etc. not included and may add up to 0.2 to 0.3 tons coal equivalent for some countries.

It may be assumed that the average for Western Europe - about 2.5 tons per capita - is the minimum essential for an adequate standard of living. Most of the under-developed countries in Asia, Africa and Latin America have a very low per capita energy consumption. Their development necessarily involves greatly enhanced demands for energy.

26. The annual per capita consumption in selected Asian countries is

shown below(Table 5):

Table 5

Country	Total energy in Kilograms of coal equivalent 1959
Afghanistan	20
Burma	50
Ceylon	101
China(People's Republic). ..	498
India	145
Indonesia	135
Iran	202*
Iraq	289*
Japan	965
Korea(Rupublic of)	214
Pakistan	56
Philippines	149
Thailand	67
Vietnam	56

* - figures for 1958

(a) Pattern of production and consumption:

27. The total production of energy in India during 1960-61 was roughly of the order of 165 million tons of coal equivalent. The commercial sources of energy are coal, petroleum and falling water. Wind power and solar, geothermal, tidal and nuclear energy may constitute future sources, subject to appropriate technological developments. Nearly 61 per cent of the energy comes presently from non-commercial sources, such as cattle dung, wood, charcoal, farm wastes, etc. as will be apparent from Table 6 below. Amongst the non-commercial sources of energy, that from animate effort has not been taken into account. This has been estimated to be equivalent to 76 million tons of coal per year.

Table 6

Source	Energy consumed (million tons of coal equivalent)	as per cent of commercial energy.	as per cent of total energy.
Coal	54.60	84.0	33.0
Oil.	9.50	14.6	5.80
Water	0.90.	1.4	0.60
Total-Commercial	65.00	100.00	39.00
Cattle dung	46.00		27.90
Fuel wood	35.00		21.20
Agricultural wastes	19.00		11.50
Total-non-commercial	100.00		60.60
Total-all sources	165.00		100.00

(b) Non-commercial sources of energy:

28. Dried cattle dung is the main source of energy for cooking and heating throughout the rural area and in many urban households as well. It has been estimated that the amount of cattle dung annually available is

1200 million tons(wet weight) of which 400 million tons are used as fuel and 215 million tons as manure, the balance being wasted. On the basis of energy content, 400 million tons of dung is equivalent to 46 million tons of coal. Wood is used as fuel both for domestic purposes as well as by some industries either directly or in the form of charcoal. The fuel-wood consumption of the country is estimated to be of the order of 60 million tons, which in terms of energy equivalent would be equal to roughly 35 million tons of coal.

29. The consumption of 60 million tons of fuel wood would involve an annual deforestation of approximately 30,000 acres of land, assuming an average yield of 2000 tons of wood per acre. The land thus denuded of its cover and binding medium becomes fit only for grazing. In a short time the land becomes impoverished even for grazing and degenerates into desert. Re-afforestation measures, selective fellings and increased production of domestic coke from coal as a substitute for fuel wood would have to be undertaken in order to conserve this valuable resource.

(b) Commercial sources of energy:

(i) Electric power

30. Large quantities of low grade coal and middlings will be available at collieries and washeries for generation of power. These locations are, therefore, well suited for coal-fired stations. Hydel stations take a long time to set up, involve relatively larger outlays and are, by their very nature, located in relatively remote localities from which the power has to be transmitted over long distances. These are, however, the cheapest source of power. The break-up of generating capacity among different types of plants is indicated below(Table 7):

Table 7

(million kilowatts)

	1951	1956	1961	1966
Hydel Plant	0.56	0.94	1.85	5.07
Coal	1.59	2.27	3.40	7.13
Oil	0.15	0.21	0.34	0.39
Gas	-	-	-	0.07
Total ..	2.30	3.42	5.59	12.66

31. Currently, the electric energy consumption in India is about 45 kwh per head of population. In 1950, it was 14 and in 1958, 35 kwh and by 1965-66 this is expected to increase to about 95 kwh per capita. This rate of increase will need to be maintained for a long period. Compared to other countries India's consumption is extremely low. In Japan per capita consumption rose from 455 kwh in 1947 to 930 in 1958; in Italy during the same period it rose from 454 kwh to 928.

(ii) Water power:

32. The potential of water power has been generally estimated to be about

41 million kw distributed as shown below (Table 8):

Table 8

		(million kw) @ 60% load factor
West flowing South Indian rivers.	..	4.35
East flowing South Indian rivers.	..	8.63
Central Indian rivers.	..	4.29
Rivers of Ganga basin.	..	4.83
Rivers of Indus basin.	..	6.58
Brahmaputra and others.	..	12.49
Total	..	41.17

33. Extensive surveys of individual project sites involving contouring, reservoir areas, flow characteristics, availability of local construction materials, etc., have to be undertaken before this potential can be more definitely assessed and harnessed. In the Third Plan 64 specific project sites are proposed to be investigated.

(iii) Nuclear Energy:

34. For a self-sufficient atomic energy programme an adequate supply of fuel material is a pre-requisite. It has been known for several decades that in the monazite sands from the beaches of the Kerala and Madras coasts India has one of the largest deposits of thorium in the world, containing no less than 200,000 tons of thorium in a concentration of over 9%. As a result of the work of the Atomic Minerals Division, during the period of the Second Plan an even more extensive monazite deposit has been discovered in the State of Bihar which contains about 300,000 tons of thorium in a concentration of over 10%. India thus has the largest known thorium reserves in the world equalling in amount the total world reserve of uranium. Several deposits of urnaium also have been discovered in various parts of the country, which are still being proved by drilling. A deposit containing several thousand tons of uranium has been established in Bihar and steps are being taken to open a mine to produce a thousand tons of ore a day. Nuclear power plants are expected to make a progressive contribution towards meeting the growing demand for power particularly in areas which are far away from coal-fields.

(c) Unconventional sources of energy:

35. Attempts to convert primary forms of energy such as solar radiation, wind motion, tidal energy, heat of the earth and oceans etc. are being made in different parts of the world. Of the several devices developed so far, solar house heating, solar batteries and wind power generators have proved reasonably successful in many places. Tidal motion has also been harnessed in some countries.

36. In India, work has been done on the development of a solar cooker, a solar evaporator and prototype windmills. A great deal of research and experimentation and several years of development work go into every device meant for catching the energy of the sun, wind or tides in an efficient and economical manner. Research schemes for tapping unconventional sources of

energy should be launched.

37. In India, a preliminary survey of wind velocities has been carried out and suitable regions favourable for utilisation of wind power have been located. It is proposed to instal shortly 200 wind mills at selected localities on an experimental basis. These mills will be made according to a design developed in India and used essentially for pumping water. Investigations are also being carried out for the development of a suitable design for small scale electricity generation. There is also a project in view for the utilisation of solar energy for dehumidification of factories.

(d) Extent of development, priority, etc.

38. The Technical Committee on Energy of the Natural Resources Committee of the Planning Commission has made programme for studies on the following items in respect of energy resources in India on a priority basis in collaboration with the concerned Ministries, Atomic Energy Commission and the concerned National Laboratories:

(i) Coal, Lignite and Coal gas.
(ii) Oil and Natural Gas.
(iii) Hydro Resources.
(iv) Atomic Energy.
(v) Fuel problems of villages.

IV. MINERAL RESOURCES

39. India has fairly abundant reserves (in terms of volume) of coal, iron ore and mica, adequate supplies of ores of manganese, titanium and aluminium, raw materials for refractories and limestone, but there is dificiency in ores of copper lead and zinc. There are no workable deposits of tin, nickel, molybdenum and elemental sulphur. Until recently, except for Digboi in Assam mineral oil was not known to occur in other parts of the country.

(a) Coal:

40. Coal is India's most important mineral asset and is the main source of commercial energy. Reserves of coal in seams of 4 ft. and over in thickness and occurring within a depth of about 2000 ft. are estimated to be of the order of 43,000 million tons. Inferred reserves are placed at an additional 80,000 million tons, i.e. the total reserves of coal proved, estimated and inferred thus comes to about 123,000 million tons. In addition, about 2000 million tons of lignite are also estimated to be available. The country's reserves of coal from about 1/50th of the total estimated world reserves, whereas the country's population is about 14 % of the total estimated world population. As a result of planned economic development, output of coal has increased rapidly in the recent past.

41. Thougn in terms of quantity the reserves appear to be large, the fact that the major portion of the reserves are of a poor quality, is a matter of serious concern. This is all the more so in the case of coking coal, the reserves of which are very small -- only about 2,800 million tons -- and it is particularly significant when viewed in the context of the fairly widespread and large reserves of good quality iron ore available in the country. The rapid increase in the output of steel visualised in the next 15 years will increase the demand for coking coal. The situation, therefore, calls for focussing attention on measures of conservation such as washing & blending, for economy in the consumption of coking coal and to investigating the possibility of producing iron and steel using non-coking coal. The position in regard to non-coking coal is satisfactory, but since the bulk of the reserves are of low grade, economy in the consumption of better grade

coal is essential.

42. Unlike in the U.S.A., U.K. and the Continent of Europe, where the ash in coal occurs segregated in layers making washing comparatively easy and cheap, Indian coals are fairly difficult to wash because the ash is uniformly distributed in the coal substance. In the process of washing Indian coals, therefore, a sizeable proportion of the coal substance gets removed along with the ash to form middlings, the proportion of which depends upon the quality of the raw coal input and the quality desired in the clean coal. The main problem facing the washeries, therefore, is one of finding a profitable outlet for the middlings produced. Such an outlet will improve the economics of washing and at the same time find a solution for the problem of disposal of middlings.

43. Yet another problem facing the coal industry is finding a market for the slack coal produced. Large thermal power stations located near washeries or in the coal-fields would be able to utilise washery middlings or slack coal. Complete gasification of slack coal or low grade non-coking coal would besides finding a use for these types of coal, also meet the ever increasing demand for domestic fuel. Similarly, low temperature carbonisation of slack coal would also provide a convenient source of domestic fuel. These measures would, besides meeting the demand for domestic fuel, help in releasing cowdung which can be more profitably used as a manure and also reduce the pressure on supplies of fuel wood and charcoal and thereby reduce deforestation and the attendant soil erosion.

(b) Mineral Oil and Natural Gas:

44. Next to coal, petroleum and natural gas are major sources of commercial energy. Until recently India had not developed any considerable domestic supplies of petroleum. However, intensive exploration during the last few years has established sizeable reserves of mineral oil in Assam, the exploitation of which has been taken up. The programme envisages an annual production of 2.75 million tons of oil and if additional reserves are proved, it would be possible to step up the production proportionately in the course of the Third Plan or early in the Fourth Plan period.

45. Besides mineral oil, natural gas, both associated and non-associated, has also been proved in Assam. Plans have been made for utilising the associated natural gas for the manufacture of fertilisers, for thermal power generation and as a source of domestic and industrial fuel.

46. Recent drilling operations in Cambay and Ankleshwar areas in Gujarat indicate a sizeable oilfield in that region and on the basis of the data obtained, plans have been prepared for exploiting the oilfind for an annual production of about 2 million tons to be achieved by 1965-66 and for its refining in a new refinery located in the region.

47. The annual increase in the demand for petroleum products which was 4-5 per cent during the last decade is expected to rise to 10-11 per cent in the current decades. The total demand which was about 7.5 million tons in 1960 is expected to rise to over 11 million tons in 1965-66. Household requirements (chiefly kerosene for lighting) represent about 25 per cent of the total consumption. The demand of the transport sector (diesel oil and gasolene) is more than 30 per cent. The share of industry is about 20 per cent, mainly in the form of furnace oil. There has been a significant increase in the consumption of middle distillates, comprising kerosene and diesel oil. The main problem is one of imbalance between production of middle distillates which cannot be varied except within limits and the

economy's requirements of middle distillates. Measures for the solution of this problem are receiving attention.

(c) Iron ore:

48. The assessment of mineral resources of the country with a view to making a quantitative and qualitative assessment of these reserves is an important task which the country has embarked upon. A recent survey of the world iron ore reserves by a Committee of U.N.Experts in 1955 has shown that India, Brazil, U.S.A. and U.S.S.R. have large reserves of this mineral and that on present indications, India comes first. Out of a total estimated world reserve of 85,000 million tons, India is estimated to have 21,000 million tons, of which 17,000 million tons are hematite, 1600 million tons magnesite and 2000 million tons siderite.

(d) Lime-stone

49. There are abundant reserves of limestone, the qualitative assessment of which, particularly from the point of view of steel plants' requirements is a matter of urgent priority. Reserves of bauxite, magnesite and gypsum are adequate to meet the country's requirements.

(e) Other minerals:

50. In regard to copper ore, lead and zinc ores, the present data shows fairly wide gap between the resources available and the requirements thereof. An intensive survey for locating fresh deposits of these metals and for assessing more accurately the reserves in occurrences already known or reported is an item of great priority. Proving of a large reserve of pyrites in Amjor area(Bihar) and the availability of pyrites associated with the copper ores in Khetri(Rajasthan), opens up the prospect of meeting a substantial part of the demand for sulphur from internal sources.

CONCLUSION

The review which we have given of the natural resources of India indicates that there is a large potential for agricultural development and industrial production. It holds out a promise of a self-reliant and self-sustained economy which could provide to the masses of the people a continually rising standard of living and more opportunities for gainful employment.

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733 E - Oct.1962 - 1,600

E/CONF.39/A/103
11 Oct. 1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A

International Atomic
Energy Agency

PROSPECTS AND PROBLEMS OF NUCLEAR POWER IN DEVELOPING AREAS

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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No. 728 PROSPECTS AND PROBLEMS OF NUCLEAR POWER IN DEVELOPING AREAS

A

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INTRODUCTION

1. The results of developments in the field of nuclear power will become strikingly apparent in the year of this conference as a rapidly increasing number of different power reactor systems become operational. Thus, by June 1962 there were 19 power stations representing 5 reactor types in operation in 6 countries of the world. Their total capacity was 1.6 million kW. It is expected that by the end of 1963 these numbers will increase to 55 stations in 10 countries with a total capacity of 4.5 million kW.

2. A further increase in nuclear power capacity is at present in preparation in all areas of the world, developed and less developed. The planning of nuclear power stations is already at an advanced stage in some of the developing countries, including Brazil, India, Pakistan and the Philippines. For 1966 it is expected that the total capacity of nuclear power in the world will be 9.5 million kW, increasing to 15 - 18 million kW in 1970.

3. The main reason for the interest in nuclear energy is that it has been technically proven as a new source of electric power. The consumption of electric power has in most under developed countries increased very sharply and more rapidly than the total consumption of energy. The possible market for nuclear power in these areas is therefore growing significantly.

4. Furthermore, coal, oil and natural gas are increasingly becoming essential raw materials for important and greatly expanding industries, particularly the petro-chemical and metallurgical industry. Several countries therefore would like to preserve some of their resources of coal, oil or natural gas for these purposes and substitute nuclear energy in the production of electricity.

5. Lastly, the economic life in several countries depends on import of coal or oil. For such countries the addition of uranium to the conventional sources of power production widens the choice of sources of supply for production of electrical energy and therefore lessens the dependence of any one of these sources. From this point of view nuclear power is attractive in regions with a relative scarcity of fossil fuels. Several of the less developed areas are in such regions. For instance the present per capita resources of fossil fuel in South East Asia (excluding China) are 1/10 of those of Western Europe and 1/60 of those of North America.

6. However, nuclear power reactors will only be developed if they offer promises of economic advantages compared with conventional plants. In the latter field there have been substantial technological advances in recent years. The cost per kWh at which nuclear power would be equal to conventional power is therefore at present moving downward. At the same time the development of nuclear power technology is progressing rapidly and it seems that nuclear power plants built now would be able to compete with conventional plants not located closely to coal or oil fields.

7. The less developed countries are naturally interested in determining the most advantageous starting time for their power reactor programme. The data required for such a decision can obviously not be summarized in this paper. It intends to give some guidance in analysis and interpretation of such data by considering successively the technical status of different power reactors, their cost aspects, the steps leading to the introduction of nuclear power, and the materials required for nuclear power production.

ASPECTS OF NUCLEAR POWER DEVELOPMENT

TECHNICAL ASPECTS

8. The technical feasibility of producing electric power from a nuclear plant has been demonstrated. The main problem now is to improve existing reactors or develop new ones which can compete economically with conventional plants under varying conditions. In spite of the fact that nuclear technology is relatively new, having come into existence twenty years ago, and the number of reactor types theoretically possible and deserving investigation is very large, the research and development work carried out so far has already resulted in producing several well-tested and reliable reactor systems. In analysing the current technological status of nuclear power plants, it may be useful to divide them into three broad categories:

(a) Power reactors already in commercial use;

(b) Power reactors promising for the near future; and

(c) Power reactors of advanced concepts whose suitability for industrial use still needs extensive technological and experimental development.

Power reactors already in commercial use

9. This group includes water-cooled reactors (boiling and non-boiling) with enriched uranium as fuel and gas-cooled reactors fuelled with natural uranium. A number of industrial nuclear power stations using reactors of these types are operating in countries with advanced nuclear energy industries and others are being built or planned in other countries, including several developing countries. Their technology incorporates the wide experience accumulated in the use of water and gases as coolants in conventional power engineering practice. Their technical equipment is produced on an industrial scale and they are less complex to service and maintain than reactors of other types.

10. Although these reactors already are in commercial use, they are constantly being improved and simplified as a result of additional experience and development in nuclear technology. They can, however, already now be purchased at a fixed price "turn-key" contract with suitable guarantees for performance.

Pressurized water reactors

11. Pressurized water reactors have been developed extensively in the USA and USSR. In the USA this system is at present regarded as the most advanced in terms of know-how and technology. This is a result of the experience which has been gained in design and operation of naval propulsion reactors, package power plants, the Shippingport, the Yankee and other large nuclear power plants. At present 400 000 kW of pressurized water reactors are in operation, and 500 000 kW under construction in USA, USSR, Italy, and Belgium.

12. The operating experience with the Shippingport and Yankee nuclear power plants has been very encouraging. The power rating of the Shippingport plant has been increased from the original 68 MW to 150 MW, and it has delivered over one billion kW hrs. The performance of the Yankee nuclear power plant exceeded earlier expectations and it is estimated that it is capable of yielding 170 MW instead of the designed 110 MW. This plant was built at a cost of about 25% lower than estimated and within the time schedule. Future improvements in this type envisage simplification in system design, various

components, and in containment. A highly improved fuel performance is foreseen.

Boiling water reactors

13. The boiling water reactor type allows boiling of the water in the core and can supply steam directly to a turbine without the use of a steam generator. This reactor type was developed later than the pressurized water reactor but has, however, developed very rapidly. In part, this is due to the fact that it has been able to take advantage of much of the extensive experience and technology developed in the pressurized water system. At present 350 000 kW of boiling water reactors are in operation and 650 000 kW are being built in USA, USSR, Italy, Japan, and West Germany.

14. The experience with these plants has been very satisfactory. The largest nuclear reactor, the Dresden nuclear power station in the USA, is of the boiling water type and has put out about 2 billion kW hrs at a high availability factor. Experience indicates that with some modification, the rating of the plant can be increased from 180 to 270 MWe. Many design variations and improvements indicating high potentialities of boiling water reactors are being explored. These improvements include internal steam separation, higher power density, simplified containment and higher utilization of fuel.

Nuclear superheat

15. The current designs of the boiling water and the pressurized water reactors produce saturated steam at relatively low temperatures (for instance, in the case of the Dresden plant, the steam produced is at 540°F and 1000 psi.) This involves the use of specially built large turbines which are relatively costly. It is expected that the production of superheated steam in reactors will have some economic advantage in comparison with reactors producing saturated steam. Nuclear superheat may be incorporated in pressurized water reactors, boiling water reactors, as well as several other types of reactors.

16. Experiments at the First Atomic Power Plant in the USSR demonstrated the technical feasibility of nuclear superheat in this type of reactor. A large nuclear power plant with reactors based on nuclear superheat is at present under construction in the Ural region of the USSR. In the United States several projects are directed at demonstrating the technology of reactors with nuclear superheat. Two nuclear superheat demonstration power plants, namely the BONUS (16 MWe) and Pathfinder (60 MWe) are under construction and will be critical by early 1963. Their operation is expected to yield valuable information on the technical feasibility and economics of nuclear superheat.

Gas-cooled reactors

17. These reactors have been developed primarily in the United Kingdom and France. The first gas-cooled power reactor, Calder Hall (UK), went into operation in 1956 and since then the installed capacity of such reactors has risen to 754 000 kW and will go up to 4 million kW by 1966, making it the leading reactor type in terms of kW installed.

18. The experience with these gas-cooled and graphite moderated reactors fuelled by natural uranium has established them as one of the reliable producers of nuclear power. Calder Hall's availability factor was 85% over a period of five years, in spite of the fact that it does not refuel during operation. Its heat output has increased by 25%. The average fuel utilization is also expected to increase.

19. These reactors have a good record of performance. To compete successfully with other types which are developing rapidly, they are, however, being improved so as to achieve higher power density with consequent reduction in size and increase in coolant temperature, and higher fuel utilization. This implies the use of enriched uranium and possible use of other coolants such as helium.

20. The Advanced Gas-Cooled Reactor (AGR) in the United Kingdom, which went critical in August 1962, using enriched uranium fuel and carbon dioxide as coolant, and the Helium-cooled HTGR in USA, to be critical in 1963, represent significant improvements over earlier gas-cooled reactors. Larger plants of this type may use pre-stressed concrete pressure vessels instead of steel ones to reduce costs.

21. There are also the semi-homogeneous gas-cooled reactors with enriched uranium oxide and uranium carbide as fuel. The fuel is dispersed in graphite which serves as the moderator as well as cladding material. Examples of this reactor type are the 40 MWe helium-cooled HTGR in USA and the 15 MWe helium-cooled pebble bed AVR in West Germany. If the uranium fuel is mixed with thorium, the utilization of fuel in these reactors may eventually be as high as 80 000 MWd/t resulting in a substantial reduction in fuel cycle costs.

Power reactors promising for the near future

22. This category includes concepts which have advanced well beyond the experimental stage and are being demonstrated in the form of prototype full-scale power plants. They have a sound basis in technology but their feasibility and technical and economic performance as central station plants has yet to be demonstrated. Commercial applications of these reactors can be envisaged in the latter half of the 1960's, if the operating experience with the prototypes proves satisfactory. These include three important types:

(a) Heavy water reactors,

(b) Organic moderated reactors,

(c) Sodium graphite reactors.

Heavy Water Reactors

23. The first heavy water prototype power reactor, NPD, with 20 MWe output, went into operation in Canada in April 1962. It was preceded by an experimental boiling heavy-water reactor at Halden in Norway in 1959. NPD has benefited greatly from the extensive technical experience existing with heavy water research reactors as well as the know-how developed with light-water reactors. The advantage of this type is the fact that the use of heavy water as moderator and coolant permits the use of natural uranium as fuel and a high fuel utilization. This makes it possible to discard the burned fuel elements without significant economic penalty, thus avoiding the need for reprocessing. Those countries which have indigenous resources of natural uranium and would like to base their nuclear power programmes on these resources, could find this feature attractive. The need for importing or producing large quantities of heavy water, however, would remain.

24. The initial operation of NPD has been very encouraging and it will provide valuable information for a large 200 MWe CANDU power reactor, scheduled for completion in Canada by 1964. A heavy water moderated and cooled reactor, R-3, in Sweden will produce 9 MW of electricity and 55 MW of steam for space heating. The 17 MWe Carolina-Virginia reactor, which due to its small size is fuelled with slightly enriched uranium, is expected to be critical late in 1962.

25. A number of variations of heavy water moderated reactors are possible through the use of other coolants such as organic substances, gas, and light water. Direct or indirect cycle, production of nuclear superheat, refuelling during operation, etc. are also possible.

26. Among the variations being tried out are organic cooled heavy water systems in Canada, Italy and Spain, a 150 MWe gas cooled natural uranium heavy water reactor in Czechoslovakia, and an 80 MWe EL-4 reactor of the same type in France.

27. Another promising variation in the heavy water concept is the spectral shift reactor which employs a varying mixture of heavy water and light water and can achieve very high fuel utilisation. No prototype of this concept is under construction at the moment.

Organic moderated reactors

28. These reactors employ an organic substance both as a moderator and coolant which gives it certain advantages compared with water cooled reactor. The organic does not react with uranium or carbon steel, which permits the use of more conventional materials. The low pressure in an organic reactor adds to its safety and it can deliver superheated steam.

29. The limitations of this system include the fact that the organic substance decomposes under irradiation, requiring new substance to be added to the extent of 0.5 to 1 lb per MWh of heat. This adds to the operating costs. The heat transfer characteristics of organic materials together with the possibility of fuel element fouling are also to be considered. Since the organic is a solid at room temperature, all the organic circuits have to be kept at 500°F, necessitating the use of steam tracing, which requires additional maintenance.

30. Based upon experience gained with the Organic Moderated Reactor Experiment, organic moderated Piqua reactor of 11.4 MWe was completed in USA and is expected to be critical by end 1962. The performance of this reactor will be of great value in establishing the suitability of this concept for central station application. If the plant is successful, a large 300 MWe plant may be built in the later 1960's. The potential improvements in the organic systems include use of organics less susceptible to radiation decomposition, higher operating temperatures, and power densities.

Sodium Graphite Reactors

31. Among the systems capable of yielding high temperature and high pressure steam to suit the standard turbines, the sodium graphite reactors seem to be a practical possibility. The first power plant of this type (the Hallam Nuclear Power Facility in the USA with an output of 75 MWe) went into operation in October 1962. It is likely that a large 300 MWe plant of this type may be built towards the end of the 1960's in the United States.

32. This system utilises the excellent heat transfer properties of sodium which, at relatively low flow rates, can extract large amounts of heat from the reactor and generate superheated steam through a heat exchanger. The low pressure of the system obviates the need for a containment shell. The drawback is that sodium reacts with water and air and also becomes radioactive. This calls for special precautions.

Power reactors of advanced designs

33. This category includes the advanced types of reactors which are still in the early stages of development and require extensive technological data and experience before their suitability for large-scale industrial applications can be established. Most of these reactors are not expected to be ready for construction for commercial use before the end of the 1960's or in the early 1970's. They include aqueous homogeneous reactors, breeder reactors of both fast and thermal type, molten salt reactors, etc.

34. In all these instances, some fundamental problems remain to be solved, including those relating to reactor physics, materials, components, fuel, control and safety. Much money and effort will have to be spent on experimental and technological testing of the reactors in this group before their technical and economic superiority over the reactors in the first two groups can be proved.

Long-term prospects of using thorium and plutonium

35. In the long run, the impact which nuclear power may have on the world energy supply will depend largely upon the ability of nuclear reactors to utilize available nuclear fuel to the maximum extent. The present day reactors which are in commercial operation burn only a fraction of the uranium fed into them. With this low utilization of nuclear fuel, the energy available from the low cost uranium ores would represent only a small portion of what is known to be available from fossil fuel reserves. However, the research and development work conducted so far has established that it is possible to achieve a very high utilization of nuclear fuel by re-using or re-cycling the unused portion of fuel left in the reactor core, and by breeding additional fissionable material from fertile material. Thus the amount of energy available from nuclear fuels will be many times that available from fossil fuels.

36. In terms of fuel utilization, the nuclear power reactors fall into three main categories, i.e. burners, convertors and breeders. A burner reactor uses only fully-enriched uranium or plutonium and burns it without producing any fissionable material during the process. A convertor reactor uses a mixture of enriched uranium or plutonium with natural uranium or thorium and while it burns this enriched material it produces considerable quantities of plutonium or the isotope of uranium U^{233} in the core, some of which contributes significantly to the heat output from the reactor. A breeder reactor is a convertor, which produces more fissionable material than it starts out with, so that at the end of the cycle there is a net gain of fissionable material. There are two types of breeder reactor; one where the neutron energies are very high, called the fast breeders, and the other where neutrons are slow, called the thermal breeders.

37. The possibility of using thorium and natural uranium as a basis for a nuclear power programme is of special interest to countries which have considerable deposits of thorium and uranium ores. A number of less developed countries, including India, Brazil and the UAR, belong to this group. It may, therefore, be useful to review briefly the technical status and future potential of thorium and plutonium based convertor and breeder reactors.

38. Thorium is an important fertile material but, unlike natural uranium which contains 0.7% of U^{235}, it contains no fissionable material and cannot be used as the sole fuel for a reactor. However, thorium together with fissionable material (either U^{235}, plutonium, or U^{233}) can be used to fuel converter or breeder reactors. If the reactor is a breeder, it will be possible,

after having accumulated an inventory of U^{233}, to operate on a thorium/U^{233} breeder cycle, with no further need of U^{235} or plutonium. The reactor fuel cycle would be sustained by fresh supplies of thorium only.

39. At the present time thorium is used as a fertile material in a few power reactors and reactor experiments. The 255 MWe Consolidated Edison Thorium Reactor (CETR), which went critical in August 1962, uses a mixture of highly-enriched U^{235} and thorium oxides. The U^{233} produced in the core is expected to contribute 10 - 20% of the heat generated. The 20 MWe Elk River Reactor, which went critical in October 1962, also employs a mixture of thorium oxide and highly-enriched uranium. Italy has considerable interest in thorium cycle and under arrangements with the United States the Elk River fuel may be re-processed and refabricated in Italy.

40. The gas-cooled semi-homogeneous reactors DRAGON in the UK and the HTGR in the USA, both scheduled for operation by 1964, are based upon fully-enriched U^{235} and thorium carbides dispersed in graphite and a considerable portion of the heat produced in these reactors is expected to come from U^{233} produced in the core. Thorium might also be used in aqueous homogeneous heavy water moderated reactors or spectral shift reactors which could be breeders. India, which has large deposits of thorium, is conducting considerable research directed toward thorium cycle.

41. All the above-mentioned reactors are basically experimental and are expected to yield valuable information. Nevertheless, the unknowns of the present time are so numerous that the number of U^{233}/thorium breeders constructed in this decade will be comparatively small. U^{233} as produced in power reactors contains small quantities of U^{232} and its daughter products, which are strong gamma emitters and must be handled remotely. Such problems will be resolved in due course and it is likely that thorium reactors will play an important part in nuclear power production in the future.

Plutonium-fuelled reactors

42. Plutonium may be produced in natural uranium thermal reactors. Thus, a country having large uranium reserves could conceivably start its nuclear power programme with the natural uranium system and produce enough plutonium over a period of time to go on to plutonium/uranium breeders. Plutonium can also be used in place of U^{235} in ordinary converter reactors.

43. Recently, the long-term desirability of using plutonium as power reactor fuel has become increasingly evident. Consequently several countries are now pursuing research and development programmes to study techniques for fabricating plutonium-bearing fuel elements, to develop remote methods for recovery of spent fuel and refabricating plutonium fuel elements, etc. The value of plutonium as reactor fuel will be determined by the cost of these fuelling operations and by fuel performance and fuel lifetime in comparison with an alternative enriched uranium fuel cycle. It is interesting to note that many developments in plutonium fuel technology, such as remote fabrication of fuel elements, might be immediately applicable to thorium/uranium-233 technology, and that techniques for producing fuel elements for thermal reactors or converters might be adapted to fabrication of fuel for fast breeder reactors.

44. Several reactor experiments and prototype power plants using plutonium have been built and are under construction. The plutonium oxide fuelled BR-5 in the USSR has operated since 1959 and plans are under way for larger (250 and 1000 MWe) fast plutonium fuelled reactors. In the USA the 16.5 MWe Experimental Breeder-2 will have a second core of plutonium and it is a fully integrated

nuclear power station with facilities for fuel fabrication by remote control and reprocessing. The LAMPRE, using molten plutonium, has been in operation since 1961. The water moderated plutonium Recycle Test Facility is developing information on recycling of plutonium. In France, the RAPSODIE reactor, using uranium oxide and plutonium oxide, is expected to go critical in 1964.

45. All the foregoing reactors and other experiments are expected to yield the essential data necessary for constructing commercial breeder reactors which may go into operation in the early 1970's. Some countries visualize that a considerable part of the nuclear power plants built after 1975 will consist of plutonium-uranium fast breeders.

COST ASPECTS

Summary of cost data

46. The aforegoing review of the technical progress of nuclear power shows that more and more information necessary for calculations of nuclear power costs is becoming available. However, only limited operational experience has so far been gained. Hence much of the technical and economic data at present available are subject to reassessment as technology continues to develop.

47. Nuclear power has advanced to the point where some reactor types if built with the technology known at present are expected to prove competitive with modern conventional power stations operating in areas where conventional fuel prices approximate 40 cents per million BTU's ($1.60 per million kilocalories). This price range prevails in several areas of the world which are not located closely to coal or oil fields. In the USA it has been announced that a boiling water reactor with a capacity of 325 MWe will be built at Bodega Bay, California, which is expected to be competitive at conventional fuel prices of 35 cents per million BTU's.

48. The main components of nuclear costs are capital costs, fuel cycle cost, and costs of operation and maintenance of the power station. These vary widely from one type of reactor to another. A brief summary of these costs is given below.

49. As regards capital costs, gas cooled, graphite moderated reactors in the 500 MWe size cost about $280 per kW of installed capacity. Water reactors in the 300 MWe size cost about $200 to $250 per kW of installed capacity. In the field of smaller reactors, a comprehensive effort at developing a variety of possible reactor systems is now yielding remarkable results. The variety of reactors which have been investigated is, however, such that their capital costs cover a wide range extending from $380 to $600 per kW of installed capacity, with light water and organic moderated reactors appearing as the leading contenders.

50. Fuel cycle costs are at present in the range of 2 to 4 mills per kWh for light water and gas cooled reactors. For heavy water reactors of the CANDU type, a fuel cycle cost of about 1.2 mills per kWh is predicted. Such fuel cost figures should, however, always be considered in the light of the cost structure of the nuclear fuel cycle which is radically different from that of conventional fuels and furthermore varies from one reactor system to another. Whereas the conventional fuelling cost is essentially the cost of fuel consumed, the cost of uranium consumed is but one of the components of the nuclear fuelling cost, and in most cases smaller than the cost of preparing and fabricating the fuel. Also, in most systems the credit for the plutonium contained in the irradiated fuel elements is an important determinant of total fuel costs

51. Thus, in gas cooled reactors using natural uranium metal fuel with Magnox cladding, the uranium consumption cost is perhaps 0.8 to 1 mill/kWh, while fabrication cost may be 1.3 to 1.7 mills/kWh and plutonium credit might amount to 0.8 to 1 mill/kWh. For light water reactors, the uranium consumption cost might be 1 to 2 mills/kWh, the fabrication cost 1 to 2.5 mills/kWh, and the plutonium credit 0.4 to 0.8 mill/kWh. In the case of heavy water reactors with natural uranium fuel for which the spent fuel is not reprocessed and for which no plutonium credit is taken, the uranium consumption cost may be about 0.4 to 0.5 mill/kWh and the fabrication cost 0.7 to 1 mill/kWh.

52. The cost of operation and maintenance for nuclear stations is not yet well established, but is expected to be in the range 0.7 to 1.2 mills/kWh.

53. On the basis of the above figures and assumptions concerning the annual charge for capital cost and the percentage of the plant's total capacity utilized per year, the generating cost per kWh can be calculated. Under the reasonable assumptions of a 10% annual charge rate and of an 80% load factor, the generating cost would be 6 to 8 mills per kWh for stations in the 300 MW range and 9 to 12 mills for stations in the 50 MW range. These figures are illustrative only and subject to the qualifications outlined in the following.

Evaluation of cost data

54. The average generating cost over the life of a specific nuclear power station is subject to a number of uncertainties covering a much wider range than those affecting the operation of a conventional unit. However, more often than not they are uncertainties about the time and extent of future savings rather than about future additional costs. Indeed, in most cases a cost ceiling may be quoted and even guaranteed by the builder of the nuclear plant on the basis of present conditions while a minimum cost is more difficult to estimate.

55. Thus, it appears unavoidable that nuclear power costs for a given reactor system will take the form of a range between an upper and lower limit. In estimating this range and drawing conclusions therefrom, several problems must be faced which might be best reviewed in the light of the objectives of any cost analysis. These are:

(a) The establishment of an estimate of total investment costs and of future fuel costs, and operation and maintenance costs, which the construction and operation of a power plant will entail;

(b) An allocation of these total expenditures to the units of energy which the power plant is expected to produce over its life or, in other words, an evaluation of generating costs;

(c) A comparison of the generating cost figure so obtained with those of other possible alternatives.

56. At each of the steps enumerated above there are some difficulties in obtaining single figures of unrestricted applicability. These questions are reviewed in the following.

(a) Estimation of total investment, fuel, and operation and maintenance costs

57. The difficulty in this field lies in making an accurate estimate of future fuelling costs. The fundamental difference with a conventional power cost assessment stems from the fact that the fuelling cost of a nuclear plant is not determined by fresh fuel prices alone. No less important is the amount of

energy which can be extracted from the fuel before it must be reprocessed or discarded and the costs incurred for its preparation and fabrication. In both aspects improvements have been so rapid and prospects for the future so favourable that present figures can only be viewed as an upper limit. On the other hand, the present prices paid for the plutonium contained in the irradiated fuel can hardly be expected to prevail for the life of the reactor.

58. There remains a series of formal difficulties which arise from inclusions or omissions of various items in the cost figures quoted by reactor builders. This applies particularly to capital costs which may or may not include such items as interest during construction, commissioning of the plant, site improvement, etc. A careful breakdown of what total cost figures actually cover is therefore indispensable.

59. Another significant problem is the extrapolation of costs quoted by one country to the conditions prevailing in another. Apart from the obvious element of transport costs, there are different adjustments of construction time and total wages and salaries to which no rule of thumb can be expected to apply and which must, therefore, be the subject of thorough investigation in each specific case.

(b) Estimation of generating costs

60. Assuming that all the initial data have been estimated with a reasonable degree of accuracy, the next problem is to derive from them a generating cost figure for the kWh's produced. Here again the estimator is faced with technical, economic and accounting uncertainties.

61. With regard to technical factors, both plant life and load factor which affect generating costs must for the time being be assumed, since no power reactor has been operated for the whole of its expected operational life. The assumptions usually made (20 years life and 80% load factor) are on the conservative side, since it is likely that nuclear stations will operate just as long as conventional stations (for which a 25 - 30 years life is usually assumed) and since utilization factors achieved in some of the recent power reactors had been of the order of 87 - 90%.

62. Just as important is the possibility of achieving a power output substantially exceeding that provided by the original design, thus lowering estimated unit capital costs proportionately. The striking improvement achieved in the power output of the Shippingport, Yankee and Dresden reactors shows the reality of such possibilities and their effect on final generating costs.

63. Among the economic factors, the interest rate used in the calculations plays a decisive role. A high interest rate will, of course, favour plants with relatively low investment (and relatively high fuel) costs, while a low rate will favour an alternate plant with higher investment costs but lower fuel costs.

64. With respect to the accounting questions, the determination of generating costs is complicated by the existence of different methods of computation. The problem of assigning to the kWh produced a unit cost which will accurately reflect the long series of expenditures incurred at different times for the construction, fuelling and operation of a power plant, is not new or specific to nuclear power although it is particularly complicated in this case because of the irregularity of the fuel expenditures and the relatively large decreases which can be anticipated in the near future. A general solution can be considered along the following lines:

(a) Selecting a point of reference in time, say the date of first full power operation;

(b) Discounting all expenditures to that date and adding them;

(c) Discounting all the expected energy production to the same date;

(d) Dividing the first discounted sum by the second.

This yields a single generating cost figure which might be interpreted in the following way. If all the kilowatt hours expected to be produced by the reactor were sold at this figure the stream of revenues obtained from sales would be exactly equivalent to the series of capital, fuel, and operation and maintenance costs required for the construction, fuelling and operation of the reactor.

65. An objection to this method is that it involves forecasts about the future which are at best uncertain. Another is that it requires a large amount of work. Consequently, approximate methods are in use in various countries which are described in a document published by the IAEA.(1) When they are applied to the reactors, fuel procurement and management conditions for which they have been designed, their results are so close to those of the above described method that they can safely be used.

(c) Generating cost comparisons for different power plants

66. The generating costs obtained for two or more power plants of the same output but with different capital, fuel, and operation and maintenance expenditures will permit an economic comparison of their merits only if they are expected to render the same services to the power system in which they will operate. This is an important qualification, especially in the case of an economic comparison between a nuclear and a conventional unit, considering that in most cases the two plants would not be operated similarly over the course of their life.

67. The very low fuel costs of a nuclear power plant will dictate its retention on base load from which it could only be displaced by more efficient successors, while the conventional unit will presumably move from base load to peak load operation at a much faster rate. Consequently, while the two plants will produce the same amount of energy during the first few years, this situation is not likely to prevail throughout their lives. If nuclear power is expected to represent a large share of the total capacity of a power system, nothing short of a computation of total system costs for each of the contemplated alternatives can yield fully dependable results.

STEPS LEADING TO THE INTRODUCTION OF NUCLEAR POWER

68. Assuming that a less developed country is interested in the possible application of nuclear power, the question arises as to what steps should be taken leading towards actual construction of a power station. There is no standard answer or approach to this question because the conditions and needs as well as the state of development differ widely from one country to another. Nevertheless, it may be useful to outline some of the important steps which are common in most cases. These steps are:

(a) A comprehensive survey of indigenous energy resources such as hydropower, coal, oil and gas. This would indicate the supply position regarding conventional energy and its cost range. If energy resources are abundant, cheap and properly distributed in relation to the load demand, then the need for any alternate source of energy such as nuclear power would not be urgent;

(b) An estimate of the demand for electric power in the area and the preparation of a long-term plan to meet this demand. This would indicate the size and timing of additional capacity which must be built;

(c) An estimate of the initial cost, operating expenses and generating costs of conventional plants to meet the projected demand and a preliminary comparison of these with the costs of a nuclear power plant. If this preliminary comparison shows encouraging prospects for a nuclear plant, a detailed economic comparison may be justified;

(d) Further detailed comparisons between conventional and nuclear power should take into account several factors such as financing, interest charges, local and foreign exchange expenditures, extrapolation of costs to the conditions of the country, and the contribution of local industry, services and materials;

(e) If an exhaustive economic comparison is in favour of nuclear power, arrangements for financing must be considered prior to calling for international bids on the basis of detailed specifications;

(f) The evaluation of bids should be undertaken very carefully and with the help of experts and consultants as necessary, so that the final selection of the type of reactor is based on the best available technical and economic information and analysis;

(g) Concurrent with these efforts it may be necessary to attend to other matters such as atomic legislation, and undertake a training programme for the technical staff.

69. In the enumeration of phases given above, no time scale is given. At least four years should be allowed for the construction and commission of a nuclear power station and about two to three years for the initial surveys and studies. This compares with about five years for a conventional thermal station project.

CONCLUSIONS

70. From the preceding survey of the technical status of nuclear power and of the cost data available, the following conclusions may be drawn:

(a) The possibility of producing nuclear electricity on an industrial scale has been demonstrated for several reactor systems operating under conditions of great reliability and high utilization factors. It is about to be confirmed for several other types expected to start operating in the near future,

(b) The generating costs expected to be achieved by some of the large reactors under construction in advanced countries would be competitive with those of conventional stations of the same size operating in relatively high fuel costs areas. These estimates still have to be fully tested since no power reactor has been in operation for more than seven years (in most cases much less);

(c) An intensive effort at developing reactors of smaller size in the 50 MW range is yielding important results. The variety of the systems investigated leads to a rather wide range of costs all of which are considerably higher than for large reactors;

(d) The question of introducing nuclear power reactors for developing countries with limited resources of conventional energy is therefore beginning to change from one of principle to one of suitable timing;

(o) The problem of timing is, however, of fundamental importance and the best possible investment of large capitals depends on its correct solution. This solution must be based on a careful analysis of existing domestic energy resources, of forecasts of future electric power demand and of the costs of alternative plans for meeting this demand. It must at the same time make allowance for the relatively long period required for the bringing into operation of a nuclear power plant, as well as for the importance of this plant for the future nuclear power programme of the country concerned.

MATERIALS REQUIRED FOR NUCLEAR POWER PRODUCTION

71. Materials required for nuclear power production include not only the nuclear fuel material, but many other materials for use as moderators, coolants, controls, cladding and structural purposes. The main and presently the only fuel material of practical importance is uranium, used in its natural form or artificially enriched in the isotope 235. The possibility of using thorium is envisaged and much research on this technique is going on throughout the world.

72. For moderators non-metals, such as natural or heavy water, organic compounds, and graphites, are mainly used but the possibility of using beryllium or beryllia for this purpose is being investigated.

73. Coolants used in atomic energy for heat exchange purposes include water, heavy water, organic compounds, gases such as carbon dioxide, nitrogen and helium, and liquid metals such as sodium. Control materials include cadmium and boron, while cladding materials include magnesium alloys, zirconium alloys, stainless steel, aluminium, beryllium and niobium.

74. Of all these materials, uranium is the one most likely to be required in large quantities. However, depending on the success of research under way, thorium and beryllium might also be required in substantial amounts. The other materials mentioned are not likely to present much difficulty in production from known sources to meet expanding needs adequately.

75. It was originally thought that world supplies of uranium would be insufficient to meet the expanding needs for nuclear energy but sustained geological search has shown this mineral to be much more plentiful than had been expected. Similarly, abundant resources of thorium minerals exist sufficient to meet foreseeable needs arising from the result of research on thorium techniques. However, it is doubtful if the world supply of beryllium minerals would be adequate to sustain a greatly expanded demand based on present prices, although research on mineral concentration of beryllium minerals might change this situation.

76. Thus, attention might be concentrated on uranium, thorium and beryllium as materials which might be in short supply in future nuclear power expansion.

77. The largest known deposits of uranium bearing minerals are found in Canada, South Africa, USA and France, while smaller commercial deposits are found in Australia, Congo, Portugal, Japan, Madagascar, Argentina and Mexico. Total known reserves of uranium recoverable at an economic price are of the order of one million tons in the western countries while known reserves of at present sub-economic uranium are about 5 million tons. The present trend of production is downward and the production in western countries in 1961 was about 35 000 tons, and production is likely to be voluntarily reduced during

the next five years. The main producers were USA, Canada and South Africa, with production of 17 350, 9720 and 5100 tons of U_3O_8 respectively. The remaining production was shared between France, Australia, Madagascar, Gabon and Portugal.(2)

78. Consumption in the next 8 - 10 years might well be below production capacity. Estimation of future requirements of uranium is difficult due to the unknown factor of military requirements which at present accounts for the main consumption. Estimates of requirements for peaceful purposes in western countries show the total tonnage required to be less than 70 000 tons total in the next five years.(3)Thus a surplus of supply over demand is assured even if no falling off of military requirements should take place.

79. Large deposits of thorium bearing sands are found in India, Brazil, Ceylon and Australia while substantial reserves of thorium (about 20% of the western total) occur in the uranium ores of Canada. The total known reserves of thorium in known deposits is of the order of 1 million tons, while it is doubtful if present annual consumption exceeds 1000 tons.

80. Present world production of beryllium is derived by hand picking from pegmatites. Recently some success has been achieved in flotation of finer grained disseminated beryllium ores, but the cost factor may limit large-scale application. Current production and consumption of beryl (containing about 11% BeO) is of the order of 10 000 tons per year, and an arbitrary estimate of known world reserves has been given as 14 000 tons of contained BeO. Obviously estimation of reserves from pegmatites is difficult, and reserves would be substantially increased if disseminated beryllium minerals could be successfully concentrated. In present conditions, and considering other expanding requirements for beryllium, reserves and production might be regarded as inadequate to meet future needs.

ROLE OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

81. One of the Agency's statutory functions is to assist the development and practical application of atomic energy, including the production of electric power, with due consideration for the needs of the underdeveloped areas of the world.

82. The Agency provides services and assistance which are useful for all its Members, but some activities are particularly or exclusively of importance for the less developed areas of the world. Of importance for all countries is the Agency's contribution in such fields as health and safety procedures, radioactive waste disposal, reactor safety and third party liability. Another contribution is the Agency's collection and dissemination of scientific information by means of conferences, symposia and seminars, and by its publication programme. Subjects of conferences etc. have been, for instance, fuel element fabrication, small and medium power reactors, reactor experiments, reactor safety, and hazards of evaluation techniques.

83. The Agency can foster group undertakings as has happened, for instance, with regard to the reactor physics programme conducted at the NORA critical assembly in Norway. It also acts as an intermediary in the supply of nuclear fuel which has been requested by the Congo, Finland, Japan, Norway, Pakistan and Yugoslavia.

84. The Agency's statutory obligations towards the less developed areas have been discharged by conducting, at the request of the countries concerned, economic power surveys such as those carried out in Finland, Pakistan,

the Philippines, El Salvador, and Yugoslavia. Once a preliminary study has given encouraging results, the IAEA can continue its assistance by providing experts to advise on such technical points as the choice of reactor type, the siting of the power plant, safety and hazards evaluation and the preparation of the necessary legislation, as well as to assist in drawing up specifications. It can also organize an international panel to study tenders for construction and arrange for the training of staff. Finally the Agency can assist by helping to obtain the nuclear fuel and by facilitating the making of financial arrangements.

85. In the field of nuclear power costs, the Agency undertakes studies in developed countries so that the best practical solutions can be evolved for the specific needs of the less developed areas. In this connection, the Agency sends periodic missions to the USA and Canada at the invitation of the Governments to follow the design, construction, operation and economics of a certain number of small and medium power reactors. The information obtained is provided to Member States.

86. Studies on nuclear power costs are only of interest if there is a reasonable degree of comparability of the results. With this in view, the Agency has in November 1961 issued a methodological study of nuclear power costing. This study is now being expanded to the economic problems which arise when a nuclear power plant is integrated in an electrical distribution network.

87. Further, the Agency has upon request provided international expert teams to perform reactor hazards evaluations. Such evaluations have been made in the Netherlands, the Philippines, Switzerland and Thailand.

88. Like the other organizations in the UN family, the Agency has a programme of the provision of experts, equipment and fellowships, financed from the Agency's own resources and from the Expanded Programme of Technical Assistance (EPTA). Several advanced countries have offered to the Agency to accept fellows from other Member States to be trained in the operation of nuclear power reactors.

89. The coming decade has been designated by the UN as a development decade. This decade will be very important for nuclear power. By the end of that period, if expectations are correct, nuclear power will cease to be a question of experiment and of testing of prototypes and will become an established part of the world's industry. The Agency is prepared to perform its role in this development.

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List of Abbreviations

BONUS	boiling nuclear superheater power station
BTU	British thermal units
EGCR	experimental gas-cooled reactor
mill	one-thousandth of a dollar
MWd	megawatt day
MWd/t	megawatt day/metric ton uranium
MWe	megawatt electric
NPD	nuclear power demonstration
OMRE	organic-moderated reactor experiment
psi	pounds/square inch
SGR	sodium graphite reactor
t	metric ton

NOTE

All sums of money are expressed in United States currency.

728 E - Oct.1962 - 1,600

E/CONF.39/A/104
11 Oct.1962
ORIGINAL : FRANCAIS

CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : A.4.2.1

France

PROGRES DES TECHNIQUES D'EXTRACTION DU CHARBON ET LEUR APPLICATION AUX GISEMENTS DES REGIONS PEU DEVELOPPEES

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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

PROGRES DES TECHNIQUES D'EXTRACTION DU CHARBON ET LEUR APPLICATION AUX GISEMENTS DES REGIONS PEU DÉVELOPPÉES

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1. La mise en exploitation des ressources minières est, pour les régions peu développées, un des moyens les plus efficaces pour élever le niveau de vie de leurs populations. C'est particulièrement le cas des ressources de charbon, en raison des possibilités considérables d'utilisation offertes par cette source fondamentale d'énergie. Il n'est donc pas étonnant de constater, dans ces régions, l'intérêt suscité par les projets visant à la reconnaissance des gisements, leur mise en exploitation ou le développement de mines existantes. Les gouvernements des pays en cause attachent, à juste titre, la plus grande importance à leur aboutissement, surtout lorsque ces projets sont associés à d'autres - par exemple ceux d'usines sidérurgiques, de produits chimiques, cimenteries, ou centrales thermiques - visant à la création de véritables complexes industriels.

2. Actuellement, si de tels projets ont déjà donné lieu à des réalisations, beaucoup sont au stade des travaux et études préliminaires dans plusieurs pays d'Asie ou d'Amérique latine dont le sous-sol renferme des réserves de charbon; dans la plupart des cas, des spécialistes de l'industrie minière des pays hautement industrialisés sont appelés à se pencher sur les problèmes ainsi posés. Mais, qu'il s'agisse de l'ouverture d'une mine nouvelle ou du développement et de la modernisation de mines existantes, le choix des solutions offertes par la technique minière moderne doit tenir compte des sujétions que l'on rencontre ordinairement dans les régions peu développées. Il est presque superflu de rappeler à ce sujet que l'absence de personnel et surtout de cadres qualifiés, l'éloignement des sources d'approvisionnement, sont peu compatibles avec la mise en oeuvre de moyens comportant du matériel coûteux dont l'emploi impose un minimum de précaution. A ce handicap s'ajoutent souvent des conditions géologiques ou géographiques particulières - gisements tourmentés, altitude, absence d'eau -et le fait que les taux de production à prévoir correspondent en général à des installations de petite ou moyenne importance qui ne cadrent pas exactement avec celles qui prévalent dans les régions développées.

3. Fort heureusement, la technique minière moderne offre une gamme assez étendue de solutions aux problèmes variés posés aux mineurs. De plus, elle se perfectionne sans cesse par l'apparition de méthodes nouvelles et de matériels nouveaux de mieux en mieux adaptés aux conditions imposées par les gisements,

les impératifs qui dirigent cette évolution étant l'efficacité et la sécurité. Or, contrairement à ce que l'on pourrait penser, ce n'est pas uniquement dans le sens d'une complexité sans cesse croissante ni dans celui d'une mécanisation de plus en plus poussée que s'opère cette évolution : des méthodes à la fois souples et sûres, n'exigeant pas l'emploi d'un matériel compliqué sont maintenant couramment appliquées pour l'exploitation de gisements de caractéristiques particulières; par ailleurs, le matériel de mine tend souvent à devenir de plus en plus robuste, maniable, et d'un domaine d'utilisation étendu. Aussi certains problèmes miniers des régions peu développées peuvent-ils être résolus en ayant recours à ces formules nouvelles, et l'objet de ce mémoire est de passer en revue quelques unes des solutions ainsi offertes grâce aux récents progrès de la technique moderne. Précisons que l'énumération qui suit est loin d'être exhaustive : les méthodes et matériels auxquels il sera fait allusion et qui seront sommairement décrits ont été choisis parmi d'autres pour l'intérêt qu'ils présentent en raison de l'importance et de la fréquence des problèmes qu'ils permettent de résoudre, et également parce qu'ils ont effectivement constitué les solutions proposées dans divers projets concernant les mines de régions peu développées.

Technique moderne des sondages de reconnaissance au charbon

4. La reconnaissance des gisements en vue de l'ouverture de mines nouvelles constitue l'un des problèmes relevant de la technique minière qui se posent le plus fréquemment dans les régions peu développées. S'agissant le plus souvent de gisements non encore exploités ou exploités à très petite échelle, les renseignements que l'on possède sur eux sont des plus restreints et c'est sur le seul résultat des travaux de reconnaissance que l'on doit compter pour calculer les réserves, établir les projets d'exploitation comportant le choix du matériel nécessaire sur lequel il sera difficile de revenir ultérieurement.

5. Or, si certains gisements peu profonds ou situés dans des régions montagneuses peuvent être reconnus par galeries, dans bien des cas on aura recours à des sondages qui devront fournir des indications à la fois nombreuses et précises, à savoir le nombre, la position et la composition des couches, la nature du charbon et celle des terrains encaissants, la présence éventuelle d'eau et de gaz. Chaque sondage aura enfin pour objet l'obtention d'une coupe stratigraphique suffisamment détaillée des terrains traversés pour que l'on puisse établir les corrélations nécessaires entre sondages voisins et en déduire la topographie souterraine du gisement. En fait, ces indications précises ne sont pas exigées des seuls sondages au charbon pratiqués dans les régions peu développées, mais, dans ces régions, la précarité des moyens de communication et parfois le manque d'eau rendent les conditions de leur exécution plus difficiles.

6. Les progrès réalisés dans la technique des sondages au charbon permettent maintenant d'atteindre ces divers objectifs pour des profondeurs allant jusqu'à 1 500 m. Ces résultats sont obtenus grâce à l'emploi d'un matériel approprié ainsi qu'à l'organisation de la surveillance géologique des sondages. Ceux-ci sont effectués par carottage avec couronnes diamantées et l'emploi du carottier double permet la récupération intégrale des carottes même en terrain friable. Enfin l'emploi de boue d'injection s'oppose au

gonflement des terrains argileux et consolide les parois du trou, ceci afin de diminuer le nombre de tubes à descendre et d'éviter la sédimentation des cuttings. La boue circulant en circuit fermé, les consommations d'eau sont faibles.

7. Le carottage intégral des terrains traversés, y compris les couches de charbon friable présente des avantages considérables par rapport aux procédés antérieurement pratiqués, qui comportaient comme pour les gisements métallifères l'emploi du carottier simple et l'injection d'eau claire, et ne permettaient de récupérer sous forme de carottes que les éléments durs des couches, lorsque celles-ci en comprenaient. L'observation des cuttings et des variations de la vitesse d'avancement, dont on devait souvent se contenter, ne permettait pas d'avoir une idée exacte de la composition des couches, et bien des erreurs d'interprétation ont été commises faute de renseignements suffisamment précis, que seule peut fournir la reconstitution intégrale, en surface, des différents éléments constitutifs de la couche. Aussi, la technique nouvelle des sondages au charbon tend-elle à se généraliser : son emploi est devenu la règle dans certains pays d'Europe occidentale notamment, où les gisements présentent souvent de nombreuses irrégularités et renferment des couches d'épaisseur et de composition variables d'un point à l'autre. Précisons par ailleurs que les vitesses d'avancement couramment obtenues pour les sondages profonds sont, en moyenne, de 6 à 8 m par jour (elles sont de 8 à 10 m pour les sondages de profondeur moyenne) et que le matériel nécessaire est maintenant bien adapté aux conditions de son emploi : il existe toute une gamme de sondeuses de capacités diverses destinées aux recherches houillères, dont certains modèles sont portés sur une plateforme automobile avec derrick rabattable, ce qui facilite considérablement les déplacements. Toutes ces sondeuses sont conçues pour le carottage au diamant, mais certaines d'entre elles, du type Rotary-combiné, permettent également l'emploi du trépan à molettes pour la traversée rapide des terrains de couverture ou stériles. Les engins auxiliaires, treuils, pompes à boue à moteurs indépendants (électriques ou diesel) sont particulièrement bien étudiés pour leurs conditions d'emploi, qui exigent parfois des puissances élevées. Les carottiers doubles, les couronnes diamantées existent pour tous les diamètres usuels. Enfin ce matériel se perfectionne sans cesse par la mise au point d'accessoires permettant par exemple la détermination de l'orientation des carottes par rapport au nord magnétique; des essais sont en cours en France pour la réalisation d'un carottier double étanche permettant d'extraire les carottes de charbon avec tous les gaz qu'elles renferment, dont le dosage et l'analyse fournissent des données extrêmement utiles pour l'établissement des projets d'exploitation.

8. La description ci-dessus montre que ce matériel spécialement adapté pour les recherches au charbon est utilisable dans les régions peu développées en raison de sa robustesse et de sa mobilité, de son équipement de moteurs diesel et des faibles consommations d'eau qu'il entraîne. Bien entendu, sa mise en oeuvre suppose le recours à des équipes hautement spécialisées placées sous la surveillance de géologues chargés d'observer les carottes, de consigner les résultats et de prélever les échantillons. Par contre, il peut être fait appel à la main d'oeuvre locale pour les travaux accessoires.

9. Nous conclurons de ce qui précède que la technique moderne des sondages de reconnaissance au charbon avec carottage intégral est applicable dans les régions peu développées; nous pensons même que son emploi s'impose pour la plupart des problèmes de reconnaissance par sondages de leurs gisements houillers; le recours à la technique ancienne avec carottier simple,

encore valable pour les mines métalliques doit être exclu dans la plupart des cas en raison des risques d'insuccès qu'elle comporte.

Technique nouvelle employée pour le creusement des galeries

10. L'aménagement des mines souterraines comporte un réseau important de galeries creusées, les unes au rocher, les autres dans les veines de charbon; par tonne extraite, les longueurs de galeries tracées dépendent de la structure des gisements et des méthodes d'exploitation employées. Pour fixer les idées, précisons qu'en 1961, dans l'ensemble des mines souterraines françaises de houille ou de lignite dont la production nette pour cette année s'est élevée à 53 201 000 tonnes, on a creusé respectivement 195 et 849 km de galeries au rocher et au charbon. Ces chiffres suffisent à montrer clairement l'importance des travaux de creusement de galeries dans les mines souterraines; les dépenses correspondantes, qui comprennent des frais de main d'oeuvre et des consommations, ainsi que des dépenses d'amortissements de matériel constituent un élément notable du prix de revient de la tonne extraite. Mais si pour cette raison l'une des préoccupations des bureaux d'études est la mise au point de méthodes de creusement tendant à réduire les dépenses par mètre de galerie creusée, ils s'efforcent d'augmenter simultanément la vitesse de creusement, elle-même génératrice d'économie, car les retards dans les préparations coûtent cher et que, d'une manière générale, en traçant vite on tend à réduire la longueur des galeries ouvertes, économisant ainsi des dépenses d'entretien.

11. La méthode la plus employée comporte l'abatage par tir et, dans les bowettes comme dans les voies de niveau, le chargement en berlines à l'aide de pelles à godets. De bons résultats ont été ainsi obtenus grâce à une bonne organisation des tâches à la spécialisation des équipes, ainsi qu'à des perfectionnements sans cesse apportés à l'outillage.

12. Au cours des dernières années, la substitution de convoyeurs à bande aux berlines dans les galeries de desserte creusées au charbon, a conduit à remplacer, dans des bassins où l'on exploite par tailles des veines faiblement inclinées, les voies de niveau souvent sinueuses du fait des ondulations des couches, par des galeries dites en direction, constituées d'éléments droits mais dont le profil en long, sous l'incidence des mêmes ondulations, présente localement des pentes incompatibles avec l'emploi de berlines. Celles-ci ne pouvant pas être utilisées même pour l'évacuation des produits du creusement, on a été conduit à rechercher un moyen de chargement pouvant être concilié avec une évacuation par convoyeur et c'est ainsi que la solution par raclage à courte distance a été expérimentée et finalement retenue. En effet, l'application de ce procédé a donné des résultats très satisfaisants notamment en France où après de nombreux essais divers modèles d'équipements ont été mis au point.

13. Ceux-ci comprennent une estacade mobile sur patins dont le bâti supporte une rampe de chargement accédant à l'orifice de déversement ainsi qu'un treuil à double tambour permettant le va et vient de l'outil de raclage. Les modèles diffèrent par les solutions permettant d'assurer la répartition des produits sur le convoyeur : dans certains cas un élément de

blindé joue le rôle de répartiteur; dans d'autres, le convoyeur à bande est directement incorporé à l'estacade et certains dispositifs qui font encore l'objet d'essais, assurent la répartition. La puissance du treuil est d'une trentaine de chevaux. Grâce à ces équipements ainsi qu'à une bonne organisation des chantiers (3 hommes par poste, marche à trois postes), des avancements moyens de 5 à 6 m par jour, avec performances atteignant 10 m sont couramment obtenus en section de 9 à 12 m2, ce qui correspond à un rendement voisin de 6 m3 par homme-poste. Ainsi la méthode est-elle maintenant généralisée pour le traçage des galeries au charbon en direction dans le plus important des bassins français. Elle l'est également pour le creusement des voies inclinées au rocher, où l'emploi des pelles est souvent difficile.

14. Tant en raison de ces bons résultats que du fait de certaines difficultés rencontrées avec l'emploi des pelles pour le chargement des grandes berlines, l'extension de la méthode par raclage au traçage des bowettes au rocher à grande section, a fait également l'objet d'essais. Des équipements comportant une estacade disposée pour le chargement direct en petites berlines, ou associée à un convoyeur de relevage permettant le chargement de berlines de 3 m3 ont été expérimentés avec succès. Des études comparatives ont montré que par rapport au chargement par pelle, le raclage ainsi pratiqué apporte des économies sensibles de main d'oeuvre, d'énergie, d'amortissement et d'entretien du matériel de chargement. Il permet enfin des avancements plus rapides.

15. Il apparaît donc que l'emploi du raclage à courte distance pour le chargement tend à se répandre dans les travaux de creusement de certains types de galeries au charbon comme au rocher. Une technique nouvelle se dessine ainsi et il y a lieu de se demander si son application aux travaux miniers des pays peu développés offre de l'intérêt.

16. Remarquons tout d'abord que dans ces pays, les problèmes qui se posent aux mineurs sont souvent des problèmes d'aménagement de mines nouvelles parmi lesquels celui du creusement d'un important réseau de galeries occupe une place prépondérante. Il s'agit aussi d'aller vite, et dans ces conditions la mécanisation des opérations de chargement s'impose dans ces travaux. En fait, celle-ci est effectivement réalisée dans beaucoup de cas, pour le creusement des galeries horizontales où circulent en général des berlines de petites dimensions, grâce à l'emploi de pelles à godets qui offrent l'avantage de se prêter aux tracés en courbe. En outre, ce sont des engins dont il existe sur le marché plusieurs modèles ayant fait leurs preuves.

17. Cependant pour le creusement des galeries inclinées, descenderies en couche ou bowettes descendantes équipées ou non de convoyeur à bande, qui constituent souvent dans les mines des pays peu développés l'appareil de sortage destiné à la remontée des produits en surface, le recours au raclage paraît s'imposer, surtout dans le cas d'une desserte par convoyeur à bande.

18. Mis à part ce cas particulier pour lequel la solution apparaît clairement, on peut se demander si d'une manière générale le raclage ne constituerait pas une solution recommandable également dans le cas du creusement de galeries horizontales rectilignes - ce qui est le cas des galeries au rocher - dans les mines des pays peu développés.

19. A son actif, ce procédé de chargement possède trois qualités : simplicité, efficacité, économie. Les estacades de chargement - particulièrement celles conçues pour le chargement direct de petites berlines - sont en effet simples et robustes et peuvent être en grande partie construites dans le

pays utilisateur. Leur emploi ne nécessite pas le recours à de la main d'oeuvre hautement spécialisée, et se prête à une bonne organisation du chantier. Par ailleurs, le chargement par raclage permet une vitesse d'avancement accrue; les mêmes équipements peuvent être employés pour des galeries de sections diverses et même pour des opérations de chargement autres que celles des produits de creusement de galerie. C'est enfin un moyen de mécanisation économique, au triple point de vue amortissement, dépense d'entretien et consommation d'énergie.

20. Il semble, en conclusion, que son emploi soit recommandable dans de nombreux cas dans les pays peu développés.

Méthodes d'exploitation de couches puissantes ou fortement inclinées

21. La technique de l'exploitation des couches puissantes ou fortement inclinées a beaucoup évolué au cours de ces dernières années. Diverses méthodes, qui autrefois auraient paru "révolutionnaires", sont maintenant couramment appliquées pour leur exploitation. Parmi celles-ci certaines sont particulièrement intéressantes par leurs possibilités d'application dans les pays peu développés : il s'agit de méthodes permettant le déhouillement intégral des couches sans qu'il soit fait appel au remblayage. La mise en oeuvre de celui-ci constitue en effet dans ces pays une sujétion très lourde et parfois prohibitive par les installations coûteuses qu'il impose, et parfois aussi par l'absence de matériau adéquat; aussi pour éviter son emploi, a-t-on recours à des méthodes avec dépilage partiel, méthodes qui ont abouti à des mécomptes : gaspillage du gisement dans tous les cas et souvent inflammation spontanée des piliers abandonnés. Dans certains pays peu développés, ces difficultés constituent le principal obstacle à un développement normal de la production.

22. Cependant le dépilage intégral et sans remblai de couches puissantes est devenu chose courante depuis quelques années dans certains bassins européens et notamment en France où l'on a recours pour ce faire, à diverses méthodes maintenant bien au point qui constituent une gamme assez étendue de solutions applicables à différents types de gisement. Nous en donnons ci-après la description sommaire.

23. Dans les couches puissantes d'une inclinaison allant jusqu'à 50°, on peut appliquer la méthode par tranches inclinées foudroyées unidescendantes. Cette méthode consiste à découper la couche en tranches parallèles aux épontes, d'une épaisseur comprise entre 2 et 3 mètres, que l'on dépile successivement en commençant par celle située au contact du toit. Chacune de ces tranches est exploitée avec foudroyage comme une veine entre toit et mur, en général par longues tailles; mais lors de l'exploitation de celles-ci, sauf pour la dernière tranche qui est sur le mur de la couche, on pose sur la sole, avant de foudroyer, un "plancher préalable" qui servira de toit artificiel à la tranche suivante. Celui-ci est constitué par des panneaux de bois préfabriqués au jour reposant sur des longerons de bois enterrés dans le charbon, ou par du grillage et des feuillards d'acier déroulés perpendiculairement au front d'abatage. Les tailles qui peuvent avoir de 100 à 200 m de longueur, sont menées comme des tailles ordinaires, avec soutènement en bois ou métallique, convoyeur blindé, abatage au marteau-piqueur ou par tir. On peut éventuellement utiliser des haveuses

si le charbon est dur, le plancher préalable suffisamment raide, et si on ne passe en tranche inférieure qu'après un certain temps.

24. Cette méthode ne présente aucune difficulté d'application si le premier toit de la couche se foudroie bien sans donner de trop gros blocs. Son application suppose un certain parallélisme entre le toit et le mur de la couche. Des variations importantes de la puissance de celle-ci conduiraient en effet à abandonner des lambeaux de charbon qui pourraient donner lieu à des feux.

25. Dans le cas de couches de puissance irrégulière n'excédant pas 6 mètres, on peut appliquer la méthode dite de la tranche unique avec sous-cavage qui consiste à prendre une seule tranche au mur de la couche et à foudroyer le charbon subsistant au-dessus de cette tranche. Ce charbon est foudroyé en même temps que le toit véritable au fur et à mesure de l'avancement de la taille par laquelle on dépile la tranche au mur, et il est chargé dans l'engin de desserte de la taille. Cette méthode est applicable aux couches de plus de 6 mètres de puissance à condition de prendre tout d'abord une ou deux tranches sous le toit avec foudroyage, et le reste par la méthode de la tranche unique avec sous-cavage.

26. Dans les gisements de couches puissantes très inclinées ou dans les amas, aux tranches parallèles aux épontes doit être substituée la méthode des tranches horizontales qui peut être employée sans remblai dans le cas des tranches unidescendantes foudroyées, ou des tranches foudroyées avec sous-cavage.

27. La méthode des tranches horizontales unidescendantes foudroyées consiste à découper le gisement par tranches horizontales que l'on dépile successivement en descendant, chaque tranche étant exploitée avec foudroyage sur plancher préalable constitué comme nous l'avons indiqué plus haut. Cette méthode s'applique bien aux très gros amas. Dans le cas de couches dont la traversée horizontale est peu importante, une dizaine de mètres par exemple, on emploie de préférence la méthode précédente avec sous-cavage, c'est à dire en n'ouvrant les galeries de desserte que dans une tranche sur deux, la tranche supérieure à la tranche en exploitation étant déhouillée par sous-cavage.

28. Pour l'exploitation des gisements de charbon assez dur en veines fortement inclinées de puissance variable, les méthodes dites par soutirage sont particulièrement efficaces. Celles-ci consistent à creuser dans le massif de charbon des galeries découpant celui-ci en piliers de faible épaisseur, 3 ou 4 mètres au maximum. Par des tirs effectués à partir de ces galeries, on déhouille ces piliers en rabattant comme dans la méthode des chambres et piliers, mais en reprenant non seulement le charbon latéral mais également le charbon surplombant.

29. La disposition des galeries de tir diffère suivant les types de gisements; elles sont le plus souvent inclinées de manière à permettre la descente par glissement spontané du charbon dans des couloirs fixes. Avant chaque tir on procède à l'exécution d'un solide barrage en bois destiné à retenir le charbon abattu que l'on soutire ensuite peu à peu, jusqu'à ce que les stériles viennent. Dans d'autres cas les galeries de tir sont horizontales. Elles sont alors équipées de couloirs oscillants avec bec pelleteur.

30. Ces méthodes de soutirage ont un champ d'application étendu : en effet elles sont employées avec autant de succès pour l'exploitation de couches verticales ayant jusqu'à 50 m d'épaisseur, que pour celle de couches inclinées à 30° seulement, ayant 6 à 8 m d'épaisseur. Elles comprennent, en fait,

un grand nombre de variantes.

31. La description qui précède de méthodes d'exploitation sans remblai permettant de réaliser le déhouillement intégral des couches puissantes ou fortement inclinées, montre que leur emploi ne nécessite le recours à aucun équipement mécanique particulier. En effet, dans les méthodes par tranches, le matériel se limite à l'équipement habituel des tailles. Dans les méthodes par soutirage, l'équipement est réduit aux engins de tir ainsi qu'à des couloirs parfois en tôle émaillée ou en métal léger.

32. Précisons par ailleurs, que ces méthodes sont sûres car elles ont fait leurs preuves. Elles permettent en outre la réalisation d'économies substantielles sur le prix de revient : les méthodes par soutirage notamment nécessitent peu de main d'oeuvre. Enfin, leur emploi ne suppose pas que le personnel chargé de les appliquer reçoive une formation professionnelle particulière. Dans le cas des tranches foudroyées la formation nécessaire ne diffère pas de celle qui est requise pour les longues tailles entre toit et mur, conduites avec foudroyage.

Préparation mécanique des charbons

33. Les charbons produits dans les pays peu développés sont souvent destinés à des emplois industriels pour lesquels ils ne peuvent pas être utilisés à l'état brut. C'est le cas notamment des charbons qui doivent être livrés à des usines de carbonisation et pour lesquels certaines teneurs en cendres ne peuvent être dépassées. Les produits sortant de la mine doivent alors subir un traitement approprié.

34. Grâce aux progrès scientifiques réalisés au cours de ces dernières années dans le domaine du lavage des charbons, des études préalables permettent de déterminer à l'avance la solution la plus correcte à apporter au problème du traitement d'un charbon brut donné, compte tenu des exigences des utilisateurs. En effet, les laboratoires spécialisés sont maintenant en mesure de prévoir après interprétation mathématique des résultats d'analyse d'échantillons, quel sera le comportement de ce charbon dans les différents types d'appareils modernes de lavage. Il est ainsi possible d'établir avec précisions les projets d'installations de traitement des charbons produits par les mines en cours d'équipement dès que celles-ci sont en mesure de fournir des échantillons représentatifs de leur production.

35. Dans son état actuel, la technique du lavage des charbons comporte la généralisation d'emploi pour les grains, c'est à dire pour les produits d'un calibre supérieur à 6 ou 8 mm, d'appareils permettant une séparation quasi parfaite des produits à laver par flottants et plongeants à la densité d'un liquide dense artificiel dans lequel ils sont immergés. Le liquide dense est réalisé par suspension de magnétite dans l'eau dans une proportion permettant d'obtenir la densité cherchée qu'il est aisé de maintenir à sa valeur de réglage. Les appareils sont à deux ou trois produits et leur capacité atteint 500 t/h dans certaines installations, mais il existe également des appareils de 20 t/h. Le lavage des fines, dont on retire préalablement les produits de moins de 0,5 mm (non traités ou traités à part), est généralement effectué dans des bacs à lit filtrant avec pistonnage pneumatique, qui sans donner une séparation aussi précise que celle qui est effectuée pour les grains à l'aide de liquide dense permettent l'obtention de bons résultats surtout pour des conditions de fonctionnement régulières et moyennant

certains soins apportés à la conduite des appareils. Ceux-ci ont également des capacités de débit très étendues pouvant atteindre 150 t/h dans les grandes installations.

36. L'emploi conjugué de bacs et d'appareils à liquide dense constitue donc l'essentiel d'une solution complète au problème du lavage d'un charbon brut donné. Toutefois, ce problème admet parfois une solution simplifiée lorsque la fraction fine du brut est destinée à un emploi n'imposant pas son lavage, par exemple lorsqu'elle doit être livrée à une centrale thermique. Dans ce cas on peut se contenter du lavage des grains dans des appareils à liquide dense, où l'on traitera tous les produits d'un calibre supérieur à 3 ou 4 mm. Suivant leur destination, les produits épurés ainsi obtenus pourront être mélangés avec tout ou partie des fines non lavées.

37. Des problèmes pouvant être résolus de cette manière se sont posés et se posent encore dans divers pays, notamment dans des pays peu développés où l'emploi d'appareils à liquide dense n'offre pas de difficulté en raison de leur simplicité et de leur grande facilité de conduite.

870 F - Oct.1962 - 1,000

E/CONF.39/A/105
12 Oct.1962
ORIGINAL : FRANCAIS

CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : A.4.2.3

France

LE GAZ NATUREL,
FACTEUR DE DEVELOPPEMENT ET D'INDUSTIALISATION

1ère Partie : L'EXPLOITATION D'UN GISEMENT DE GAZ NATUREL,
L'EXEMPLE DE LACQ

Par M. André BOUILLOT,
Directeur Général de la Société Nationale
des Pétroles d'Aquitaine.

2ème Partie : LE GAZ NATUREL
ET LES PAYS EN VOIE DE DEVELOPPEMENT

Par M. FERNIQUE NADAU des ISLETS,
Président Directeur Général
de la Société Française d'Etudes
et de Réalisations d'Equipements Gaziers

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

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1ère Partie

L'apparition du gaz de LACQ dans une région totalement dépourvue d'activité industrielle est un phénomène remarquable dont les effets peuvent à juste titre être retenus comme exemple pour les pays en voie de développement.

La Société Nationale des Pétroles d'Aquitaine crée en 1941 a découvert successivement en 1949 le gisement d'huile de LACQ Supérieur et en 1951 le gisement de gaz naturel de LACQ Profond.

Le gisement de gaz se signale dès l'abord par un ensemble peu ordinaire de caractéristiques défavorables. La profondeur moyenne de la couche productrice est de 4.000 mètres, le gaz au moment de la découverte était sous pression de 570 kilos par centimètre carré et à une température de 140°. Son analyse y fait apparaître 15 % d'hydrogène sulfuré et 10 % de gaz carbonique.

Tous les problèmes techniques que posait la mise en exploitation de ce gisement furent néanmoins rapidement résolus en même temps que fût construite l'Usine de Raffinage indispensable pour séparer et rendre utilisables les composants du gaz brut.

La production annuelle se résume ainsi :

- gaz épuré	4.800 millions m3
- soufre	1.400.000 tonnes
- essence	360.000 m3
- butane	80.000 tonnes
- propane	57.000 tonnes
- étylène obtenu par transformation de l'éthane	25.000 tonnes

Actuellement le gaz épuré est réparti de la façon suivante entre les différentes régions de FRANCE qu'il dessert :

- Sud-ouest	38 %	- Région parisienne	28 %
- Centre-ouest	11 %	- Centre-est	23 %

Par grandes catégories d'utilisateurs, la répartition est la suivante :

- Centrales thermiques	31,5 %
- Distributions publiques	23,5 %
- Industries utilisant le gaz comme énergie	25,5 %
- Industries utilisant le gaz comme matière première	18 %
- Gaz carburant	1,5 %

Les investissements correspondants sont de l'ordre de 1,2 milliard de NF. sans tenir compte du réseau de transport qui a coûté environ 600 millions de NF.

Enfin, le tableau suivant montre la part de plus en plus grande que le gaz de LACQ a pris dans le bilan énergétique de la FRANCE :

	Millions de tonnes équivalent charbon		
	1954	1957	1961
I - PRODUCTION			
Charbon	57,4	61,4	55,2
Hydroélectricité	9,7	9,8	15,3
Energie nucléaire	-	-	0,1
Pétrole brut	0,6	1,8	24,2
Gaz naturel	0,4	0,7	5,6
Total	68,1	73,7	100,4
% gaz naturel	0,6	0,9	5,6
II - BESOINS TOTAUX	103	125	150

Quels sont les faits essentiels qui ont marqué l'insertion de LACQ dans le complexe économique français ?

Avant LACQ, les Basses-Pyrénées étaient une terre agricole à propriété très morcelée vivant à peu près de ses cultures, de son élevage et de son artisanat, les échanges avec le reste de la FRANCE, sauf pour quelques industries d'avant-garde, comme Turboméca, se limitant au tourisme d'été, et à l'énergie hydroélectrique tirée des chutes d'eau des Pyrénées.

Le gisement de LACQ a donc été mis en exploitation dans une région sous-développée, à économie pseudo-autarcique, à grande distance des régions économiquement développées de la FRANCE.

La destination du gaz de LACQ a été donnée sous la direction de l'Etat et a été triple :

a) développement d'un complexe industriel à proximité immédiate,

b) alimentation d'une région sous-développée à courte (sud-ouest) ou moyenne (ouest) distance,

c) alimentation de zones industrielles ou urbaines à longue distance.

L'apparition du gaz et son raffinage sur place ont attiré à proximité de sa source un ensemble de consommateurs donnant naissance à ce qu'on appelle le "complexe" de LACQ. Il s'agit d'abord d'une Centrale Thermique bâtie à Artix recevant directement son combustible de l'Usine de la S.N.P.A. et comportant trois groupes d'une puissance respective installée de 125.000 KW.

L'Usine d'Artix alimente l'usine de production d'aluminium de PECHINEY à Noguères, autre localité voisine de LACQ. D'une capacité actuelle de production de 90.000 tonnes par an à laquelle s'ajoute l'accroissement de la capacité de l'Usine de Lannemezan due aussi à l'emploi du gaz, cette installation a abouti à une augmentation de 50 % de la production française d'aluminium qui représente maintenant 5 % de la production mondiale. Les investissements s'étendent à 200 millions de NF et l'effectif global à 525 personnes.

A Pardies, autre localité de la région située à quelque cinq kilomètres de LACQ, un ensemble d'industries chimiques qui utilisent à la fois le méthane comme matière première et comme combustible se sont établies en communauté sous la dénomination d'AQUITAINE-CHIMIE. Procédant d'abord à un cracking du méthane cette Société fabrique de l'acéthylène et de l'ammoniac. A partir de ces deux produits de base, il est procédé à la fabrication de l'urée, des engrais azotés et singulièrement de l'ammonitrate, de l'acétaldéhyde, du butanol, du chlorure de vinyle, et grâce à l'utilisation des gaz de queue, du méthanol. Les investissements ont été de l'ordre de 300 millions de NF pour un effectif de 800 personnes.

Enfin à Mont, une usine implantée par ETHYLENE PLASTIQUE traite une partie de l'éthylène produite à l'Usine de LACQ et la transforme en polyéthylène, matière plastique de base pour l'industrie secondaire.

A l'intérieur de son Usine, la S.N.P.A. a été amenée à étendre son champ d'activité en se tournant vers la pétrochimie qui lui permet, en partant des produits de base obtenus directement du gaz, de procéder à des transformations aboutissant à des produits chimiques d'une valeur plus grande et dont le marché dans l'actuelle conjoncture est largement preneur. Dans cet ordre d'idées, elle va produire du benzène et du cyclohexane, développer sa production d'éthylène, fabriquer du polyéthylène, du styrène et du polystyrène. A une échelle moindre, l'Usine de LACQ produit encore du méthyl mercaptan, de la thiourée et d'autres composés thiorganiques du soufre.

L'effet de la mise en exploitation de LACQ ne s'est pas limité à la région voisine du gisement. Nous avons déjà cité l'expansion de l'usine d'aluminium de Lannemezan. Dans un même ordre d'idées, les azotiers de la région qui utilisent le gaz naturel comme matière première ont été les grands bénéficiaires de l'invention de LACQ.

Se sont respectivement la S.P.A. Lannemezan, Pierrefitte et enfin l'Office National Industriel de l'Azote (ONIA) dont les résultats de 1960 faisaient état d'une production annuelle de 184.000 tonnes d'ammoniac avec des pointes de 650 t./jour.

Ainsi, la découverte du gaz de LACQ a permis un développement rapide de l'économie locale. On a estimé que de 1954 à 1959 la valeur ajoutée des entreprises exerçant leur activité dans le département des Basses-Pyrénées a crû de 9,6 % par an contre 4,5 % dans l'ensemble du pays. Plus du tiers de cette augmentation est imputable directement ou indirectement à l'exploitation du gaz de LACQ.

Cette croissance de la valeur ajoutée a entraîné celle des ressources des ménages qui ont progressé de 37 %, soit 6,5 % par an contre 4,6 % pour l'ensemble de la FRANCE.

Le revenu annuel par habitant était en 1954 de 274.500 AF. Il est passé en 1959 à 325.000 AF marquant un progrès de 5,5 % l'an contre 3,4 % pour l'ensemble de la FRANCE. Plus de la moitié de la masse salariale versée par les Sociétés est imputable au complexe de LACQ.

Enfin, la croissance simultanée des ressources des ménages et des entreprises a entraîné celle des recettes des Administrations. L'Etat est en fait le grand bénéficiaire de l'opération avec, en 1959 une augmentation de 67 % de ses encaissements, qui met les Basses-Pyrénées au cinquième rang des départements français sous ce rapport.

Il peut être aussi intéressant de retenir que les investissements dans la seule zone de LACQ dépassent 220 milliards AF étalés sur dix ans, que 16.700 logements ont été achevés, dont le quart peut être considéré comme la conséquence directe de l'implantation du complexe, que les équipements publics, les voies de communication terrestres, ferroviaires et aériennes ont été considérablement améliorées et que l'enseignement enfin progresse de façon favorable.

Intéressantes à noter sont également les mesures prises pour développer, à la faveur de la mise en exploitation du gisement de LACQ, l'économie régionale. Par des procédés qu'on retrouve en Algérie pour le gaz d'Hassi R'mel, ou plus récemment aux Pays-Bas, on a cherché par des réductions de prix à accélérer les phénomènes d'industrialisation régionale. Mais en dehors des industries du feu (aciéries, cimenteries, céramique) où le prix de revient de la thermie a une grosse importance, ou des industries chimiques où le gaz sert de matière première, le prix du gaz naturel ne s'est pas révélé un facteur important de déplacement d'industries.

Sur un plan plus étendu, la mise en oeuvre du programme de LACQ, a conduit à développer en FRANCE la fabrication d'une série de matériels qu'il fallait auparavant importer car elle a provoqué des investissements plus de dix fois supérieurs à ceux engagés dans la prospection préalable à la découverte du gisement.

Le développement de LACQ, dans une région d'économie généralement archaïque, a par sa rapidité, mis en évidence des phénomènes particulièrement intéressants. Cette rapidité a conduit à superposer à des processus d'industrialisation locale spontanée dont l'extension ne peut être que très lente :

1°) la création d'industries de base n'assurant qu'un nombre relativement restreint d'emplois,

2°) des transports à longue distance vers des régions où le gaz a permis, dans des délais assez courts, des modernisations d'équipement et de procédés.

2ème Partie

On sait la place de plus en plus grande que le gaz naturel occupe dans le bilan énergétique des pays qui disposent de cette richesse.

Sa mise en oeuvre - qui doit naturellement tenir compte des besoins et des possibilités du pays, puis être harmonisée avec celle des autres facteurs économiques (matières premières, capitaux, main-d'oeuvre qualifiée, ressources énergétiques autres que le gaz...) ne peut que favoriser la création de richesses et l'élévation du niveau de vie des populations. Elle comporte l'établissement d'un "plan gazier" concernant :

- d'une part, les industries existantes susceptibles d'être converties au gaz,
- d'autre part, l'implantation d'industries nouvelles utilisant le gaz comme source d'énergie ou comme matière première.

En classant les applications industrielles du gaz naturel en fonction de critères tels que : l'importance de la consommation, les débouchés, l'emploi, les investissements nécessaires..., il sera possible de dégager un ordre de préférence pour les opérations à réaliser dans des économies de types divers.

Il se peut d'ailleurs, que la ressource en gaz naturel d'un pays en voie de développement, excède les possibilités d'absorption à long terme de l'économie interne, dans l'hypothèse la plus favorable. On devra alors envisager l'exportation des surplus, soit au moyen de canalisations à haute pression, soit en passant par la phase liquide. Les recettes provenant des ventes de gaz à l'Etranger procureront des devises et réduiront d'autant les charges de transport et de distribution de ce fluide à l'intérieur du pays.

Il n'en reste pas moins qu'on doit toujours chercher à placer sur le marché intérieur le plus grand volume possible du gaz naturel produit sur le sol national, car il est plus rentable d'exporter des produits fabriqués en employant ce gaz comme combustible ou comme matière première que d'exporter le gaz lui-même.

1°) Consommations et débouchés

a) Consommations

Le classement des industries qui utilisent le gaz naturel peut être esquissé de la manière suivante :

Dans un premier groupe, figurent les secteurs qui réalisent les plus fortes consommations et paraissent offrir les plus larges débouchés :

- production d'électricité,
- industries chimiques,
- sidérurgie et métallurgie générale,
- industrie du ciment.

Viennent ensuite :

- les industries mécaniques et fabrications métalliques avec la construction électrique,
- les industries des briques et tuiles et celles de la céramique,
- l'industrie du verre.

D'autres industries telles que :

- la métallurgie des métaux non ferreux,
- les industries du bois et du papier,
- les industries alimentaires,
- les industries textiles et du cuir,

ont parfois recours au gaz naturel pour une fraction notable de leurs besoins thermiques (en ITALIE notamment).

Les consommations par établissement sont particulièrement élevées dans l'industrie électrique, l'industrie chimique, la sidérurgie et l'industrie du ciment.

Dans une centrale électrique comme celle de Lacq Artix, qui comporte 3 groupes de 125 MW, chaque groupe fonctionnant en base peut absorber 750.000 m3 de gaz naturel par jour, en sorte que l'usine pourrait consommer 800 M. m3 par an.

La consommation d'une usine de synthèse est, aussi, très importante en général : 250 M. m3 par an pour le complexe de Pardies.

Une cimenterie de taille moyenne (200.00 t/an) peut consommer de 30 à 40 M. m3 de gaz naturel.

Une verrerie importante (60.000 t/an) : 20 M. m3.

b) Débouchés

Dans les pays en voie de développement, s'il y existe déjà une industrie, celle-ci constitue un premier marché potentiel pour le gaz naturel. Ou bien elle est alimentée au moyen de combustibles d'importation, auquel cas sa conversion au gaz naturel aurait l'avantage d'économiser des devises ; ou bien elle utilise des combustibles nationaux (charbon hydrocarbures liquides, bois...) et il y aurait alors lieu d'examiner si le prix de revient du gaz naturel rendu chez l'utilisateur justifie cette conversion, compte tenu des investissements que celle-ci comporte.

Par ailleurs, il conviendra d'envisager l'implantation dans des régions favorablement situées - en particulier, si cela est possible, à proximité du ou des gisements - d'industries grosses consommatrices de gaz (centrales électriques, usines pétro-chimiques, fabriques d'engrais, cimenteries ... éventuellement sidérurgie avec procédés de réduction directe) ou d'électricité produite à partir du gaz (production d'aluminium, électro-chimie, électro-métallurgie,...). L'énergie intervenant pour une part notable dans les prix de revient de ces industries, le fait pour elle de disposer en abondance de gaz et d'électricité à bas prix doit réduire leurs coûts et faciliter l'écoulement de leur production sur les marchés intérieur et extérieur.

Si on considère maintenant le cas d'un pays où l'industrie est pratiquement inexistante et que la découverte d'un gisement de gaz naturel incite à se moderniser, le "plan gazier" se trouvera nécessairement inclus dans un programme général de mise en valeur du pays.

Les problèmes humains (préparation psychologique de populations qu'il faudra initier progressivement à la vie industrielle, formation de techniciens, de cadres et d'ouvriers qualifiés), économiques (notamment en ce qui concerne la création de l'infrastructure indispensable...), administratifs, financiers ... devront être abordés en même temps que ceux posés par l'utilisation du gaz naturel.

2°) Emploi

C'est l'industrie lourde qui permet de réaliser, par établissement, les consommations de gaz naturel les plus fortes et les plus régulières.

Par contre, elle crée peu d'emploi si on la compare aux industries légères et d'une manière générale, aux industries de transformation.

Ainsi l'effectif d'une centrale thermique représente moins de 0,2 personne par M. m3/an.

Une installation de réduction directe de minerai de fer par le procédé H. Iron : environ 0,35 personne par M. m3/an.

Un complexe pétrochimique dont la consommation annuelle de gaz naturel est de l'ordre de 250 M. m3 : 3,2 personnes par M. m3/an.

Une cimenterie de 4,5 à 6 personnes par M. m3/an.

Une grosse verrerie de 20 à 25 personnes par M. m3/an.

Une céramique de 320 à 360 personnes par M. m3/an.

Pour les grés et faïences sanitaires, on emploie approximativement 200 personnes par M. m3/an.

Par contre, la fabrication industrielle des produits rouges, exige peu de main-d'oeuvre : 35 personnes pour une unité capable de produire 40.000 t/an en consommant 3 à 3,2 M. m3 de gaz naturel, soit : 10 à 12 personnes par M. m3/an.

Pour les industries de transformation, on peut avancer les chiffres approximatifs suivants :

- Industries du traitement du bois, de la pâte à papier et du papier : 60 à 70 personnes par M.m3/an
- Industries des textiles et du cuir : 240 à 250 personnes par M.m3/an
- Industries mécaniques, fabrications métalliques, constructions électriques : 500 personnes par M.m3/an
- Industries agricoles et alimentaires : 550 personnes par M.m3/an.

3°) Investissements

On trouvera, ci-après, un ordre de grandeur des investissements qu'il faudrait envisager pour la seule création d'usines susceptibles de consommer d'importants volumes de gaz naturel dans des pays en voie de développement.

Industries	Investissements par m3/an de gaz naturel consommé (N F)
Production d'électricité	0,35 à 0,40
Réduction directe de minerai de fer par le procédé Hyl et H. Iron	0,45 à 0,50
Synthèses chimiques	
Ammoniac ..... (suivant la taille des ateliers)	1,40 à 1,80
Acéthylène	0,50

Complexe de Pardies	220 t/j. d'ammoniac 76 t/j. d'acéthylène 100 t/j. de méthanol 70 t/j. d'acéthylène	1,20

Ciment

Unité importante	0,70
" moyenne	1 à 1,20
" petite	1,25 à 1,35
Produits rouges	0,85 à 0,90

Verre

verre plat	
grosse unité	2
petite unité	4 à 4,50
verre creux	
grosse unité	2
petite unité	2,50 à 3

Industries céramiques

vaisselle de faïence	
unité importante	3,50 à 4
" moyenne	4,50 à 5
" petite	7 à 3
grés et faïences sanitaires	9 à 10
carreaux de falence	20

Industries textiles

filature de coton	3,50

En conclusion le gaz naturel, s'il est judicieusement employé, peut contribuer très efficacement à l'expansion et à l'industrialisation d'un pays.

Lorsque ce pays aura atteint un degré suffisant de développement, on devra se préoccuper d'exploiter le plus rationnellement possible les installations de production et de transport du gaz naturel. En raison de la prépondérance des charges fixes dans la structure de son prix de revient, il y aura intérêt à rechercher pour ce gaz des marchés importants et concentrés, comportant des utilisations régulières ou facilement modulables. En combinant la desserte d'une clientèle industrielle et commerciale avec l'alimentation de distributions publiques, il sera possible de réaliser une exploitation très souple, particulièrement satisfaisante du point de vue économique. Au besoin, tarification appropriée pourra faciliter la sélection des consommateurs et les inciter à moduler convenablement leurs enlèvements.

866 F - Oct.1962 - 1,600

E/CONF.39/A/105/Corr.1
15 Nov.1962
ORIGINAL : FRANCAIS

CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

R E C T I F I C A T I F

Au lieu de "par M. André BOUILLOT, Directeur Général
de la Société Nationale des Pétroles
d'Aquitaine",

lire : "par M. de BAUDSAN, Délégué
aux RelationsExtérieures
de la Société Nationale
des Pétroles d'Aquitaine"

866 F - Nov.1962 - 1,000

E/CONF.39/A/106
12 Oct.1962
ORIGINAL : FRANCAIS

CONFÉRENCE DES NATIONS UNIES
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Point de l'ordre du jour : A.5.1.4

France

INTERET ET METHODES DE FORMATION DES INGENIEURS GEOLOGUES ET TECHNICIENS FRANCAIS ET ETRANGERS AU B.R.G.M.

Par Raymond LEFEVRE,
Chef du Département des Relations Extérieures
du Bureau de Recherches Géologiques et Minières

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

N° 1088
A.5.1.4.

INTERET ET METHODES DE FORMATION DES INGENIEURS GEOLOGUES ET TECHNICIENS FRANCAIS ET ETRANGERS AU B.R.G.M.

par

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du Bureau de Recherches Géologiques et Minières

1.- Les problèmes que pose la formation des ingénieurs des Mines, des géologues et des techniciens de la recherche géologique et minière ont une solution traditionnelle qui garde toute sa valeur : c'est l'enseignement scientifique et technique préparatoire à la profession, fourni par l'université et les grandes écoles spécialisées, sanctionné par l'examen ou le concours.

2.- Mais l'accélération du progrès scientifique et technique a pour corollaire, dans les disciplines de la géologie et des mines comme dans la plupart des activités scientifiques, un besoin sans cesse croissant de spécialistes, et une spécialisation toujours plus poussée des techniques. L'apparition de spécialités nouvelles, qui était un phénomène exceptionnel au 19ème siècle, est en outre devenue aujourd'hui un évènement quasi banal de la vie scientifique.

3.- Ces faits sont bien connus. Ils expliquent que dans tous les secteurs de la science et de l'industrie la formation initiale de l'ingénieur ne soit plus considérée que comme une base de départ. Ils expliquent la multiplication des stages, des colloques, de toutes les formes d'échanges et le succès des formules de "recyclage".

4.- La géologie et la technique minière ne font pas exception. Le B.R.G.M., comme la plupart des grands établissements publics et des grandes sociétés privées, a expérimenté et développé un ensemble de pratiques dont la variété peut donner une image assez complète des solutions possibles et des obstacles auxquels elles se heurtent parfois.

5.- La formation des spécialistes se présente sous deux aspects distincts et d'ailleurs intimement complémentaires : d'une part, la spécialisation proprement dite qui n'est souvent qu'une nouvelle étape dans un rameau "super-spécialisé" d'une technique déjà très particulière ; d'autre part, l'ensemble des mesures propres à conserver ou à remettre le spécialiste au courant des recherches et des progrès faits par d'autres dans son propre champ d'action.

6.- Le premier problème est traité par l'utilisation du réseau d'organismes existant en France et à l'étranger avec lesquels le B.R.G.M. collabore. Nous envoyons des ingénieurs faire des stages de recherche ou d'étude, quelquefois prolongés, dans certains instituts universitaires et surtout, nous en envoyons dans des établissements ou des sociétés dont nous recevons à notre tour les spécialistes. Citons un exemple : la chimie nucléaire est propre à rendre d'appréciables services en matière de géologie appliquée. Trois de nos ingénieurs ont poursuivi chacun à Saclay, au Commissariat à l'Energie Atomique un stage d'une année pour se former aux techniques d'emploi des isotopes

en matière d'analyse chimique. Nous recevons de façon corollaire des stagiaires au B.R.G.M. dans les disciplines où nous sommes spécialisés. C'est ainsi que l'Institut de Géologie et de Recherches du Sous-Sol de Grèce a envoyé en France depuis une dizaine d'années huit géologues qui sont venus chacun pendant une année se spécialiser au B.R.G.M. dans l'hydrogéologie.

7.- On pourrait multiplier ces exemples. Contentons-nous de souligner que de tels échanges sont chaque année plus fréquents et plus nécessaires.

8.- La création de spécialités nouvelles pose un problème plus embarrassant. Il s'agit par définition d'un secteur neuf dont l'importance s'est révélée telle que son organisation systématique devient indispensable. L'université y répond souvent par la création d'un institut à la direction duquel elle appelle un des pionniers de la nouvelle discipline. Un organisme tel que le nôtre crée un nouveau service.

9.- Si nous avons la chance de compter parmi nos collaborateurs un des défricheurs de la nouvelle spécialité, il va s'agir de grouper autour de lui une équipe dont il assurera lui-même l'initiation. Mais souvent les défricheurs sont si rares que nous n'en trouverons point dans nos propres cadres. Il faut donc spécialiser à l'extérieur les techniciens dont nous avons besoin , ou recruter un chef de file déjà spécialiste.

10.- L'une et l'autre solution sont utilisables. Disons que la première est préférable lorsqu'il s'agit de recherche fondamentale et que l'on rejoint alors les solutions que nous évoquions plus haut : les stages de longue durée.

11.- Dans le cas de la recherche appliquée, il est plus impérativement nécessaire que l'animateur du nouveau service ait déjà vécu dans un contexte d'applications techniques ou de travaux industriels, et le recrutement pur et simple d'un expert chargé de former des élèves sera la solution la plus logique.

12.- Le "Département de Valorisation des Minerais" du B.R.G.M. fournit une assez bonne illustration de ces procédures. L'importance et la complexité croissante des questions de traitement et d'enrichissement des minerais ont rendu, il y a plusieurs années, nécessaire la création d'un service spécialisé chargé de suivre le progrès des techniques en ce domaine. Mais le problème était ancien, de nombreux procédés étaient connus, des spécialistes disponibles. Le B.R.G.M. a donc pu choisir parmi ses collaborateurs le noyau initial de ce département et ses ingénieurs ont complété et prolongé ensuite leur formation déjà satisfaisante par des stages dans les organismes d'étude de la sidérurgie ou dans certains complexes industriels. Mais, ce même département, évoluant selon la loi de complexité et de spécialisation croissante qui est la nôtre, a dû très vite créer des sections spécialisées. Nous citerons l'exemple de la section d'hydrométallurgie qui a été récemment ouverte. Ce n'est pas là une technique nouvelle, et la plupart des grandes sociétés qu'elle intéresse ont créé en ce domaine leur instrument de recherche appliquée. Mais l'équivalent désintéressé, dans le domaine de la recherche nationale, n'existait pas encore. La solution adoptée a été cette fois le recrutement direct d'un ingénieur étranger ayant une grande expérience pratique de l'hydrométallurgie. Autour de lui sont rassemblés des chimistes sans spécialisation préalable qu'il lui appartient de former à la métallurgie par voie humide.

13.- Pour le maintien des spécialistes dans le courant du progrès scientifique et technique, le rôle des colloques, conférences, séminaires, congrès, etc.. est capital et il serait superflu que nous cherchions ici à le prouver. Contentons-nous d'en rappeler le rôle décisif. Mais la nécessité et l'efficacité des colloques internes méritent d'être soulignées. Ils sont à la recherche ce que les relations publiques sont à l'information. La formule en est appliquée systématiquement au B.R.G.M. et les journées d'études que nous organisons chaque année apportent à nos spécialistes un enrichissement réciproque, en même temps qu'une vue synthétique de notre orientation technique et des directions dominantes de nos recherches et de nos activités.

14.- Mais le B.R.G.M. n'a pas une vocation exclusivement nationale et son rôle est d'intervenir n'importe où dans le monde.

Sa collaboration, en matière de formation, avec les sociétés privées et les organismes officiels étrangers ne se pose dans des termes différents de ceux que nous venons d'exposer tant qu'il s'agit de pays bien pourvus de cadres techniques nationaux.

15.- Il en va en revanche tout autrement de notre coopération technique avec les pays en voie de développement du tiers monde.

16.- La première barrière qui s'oppose à l'envoi de nos ingénieurs à l'étranger comme à la formation d'ingénieurs étrangers dans nos services, nos laboratoires et nos chantiers, est la barrière linguistique.

17.- S'il existe pour l'enseignement accéléré du français aux étrangers d'excellents instruments (Centre audio-visuel de l'Ecole Normale Supérieure de St-Cloud, Centre d'enseignement de Besançon, par exemple) où les stagiaires étrangers que nous recevons subissent un pré-stage linguistique, nous avons dû conclure que rien de vraiment satisfaisant ne répondait à nos besoins propres pour la préparation et surtout le perfectionnement en anglais de spécialistes qu'on peut difficilement distraire à temps plein de leur activité professionnelle, même pour quelques semaines. Ceux-ci ont le plus souvent des connaissances linguistiques "visuelles" élémentaires d'une part, techniques de l'autre, mais ne comprennent et ne s'expriment que très mal en anglais et en espagnol. C'est pourquoi le B.R.G.M. a été l'initiateur et est l'animateur principal d'un "Bureau de Préparation Linguistique des Experts" qui dispense en anglais et en espagnol un enseignement audio-visuel spécialement conçu pour des spécialistes se rendant à l'étranger et perfectionne les techniciens de vingt-cinq des plus grandes sociétés françaises.

18.- La formation de géologues et d'ingénieurs étrangers constitue la contrepartie nécessaire de l'intervention de la technique française hors de France.

19.- La formation complète de géologues et d'ingénieurs étrangers en France est hautement souhaitable et des bourses sont données à cet effet par notre gouvernement. Dans ce domaine le B.R.G.M. joue souvent le rôle d'initiateur en proposant des candidats choisis parmi les spécialistes avec lesquels ses experts ont été en contact et ont pu apprécier. Il joue toujours le rôle de conseiller en proposant le programme d'études et en suivant au cours de sa scolarité la progression de l'intéressé et sa spécialisation éventuelle.

20.- Plus nombreux parce que moins coûteux sont les stages de courte durée (trois mois à un an) pour lesquels des bourses sont accordées par le Ministère français des Affaires Economiques. Là encore le B.R.G.M. joue un rôle fréquent d'initiateur et constant d'organisateur, mais il dispense en outre souvent lui-même la formation sollicitée par l'intéressé. C'est ainsi que nous recevons chaque année plusieurs dizaines de stagiaires d'origine et de spécialisation diverses.

21.- En 1961, le B.R.G.M. a ainsi reçu des stagiaires en provenance de vingt et un pays parmi lesquels la République Argentine et l'Iran ont envoyé le plus grand nombre. Les principales spécialités que viennent étudier actuellement les ingénieurs étrangers sont, par ordre de fréquence, la géochimie et la prospection géochimique, l'hydrogéologie, la géophysique, la géotechnique (applications de la géologie au génie civil).

La formation de stagiaires étrangers exige, elle aussi, une collaboration de plus en plus étroite entre les entreprises d'activités voisines ou complémentaires avec lesquelles nous travaillons en liaison en France et dans le monde. Car l'ingénieur étranger vient souvent avec le souci de se perfectionner dans des domaines très précis et un plan de

travail conçu en fonction de ses responsabilités et de ses travaux actuels ou futurs.

22.- Les recherches pétrolières sont en dehors de notre compétence, et tel ingénieur désireux d'enrichir ses connaissances dans la géophysique devra effectuer un stage dans les deux secteurs où elle joue un rôle important : le secteur minier (au B.R.G.M.) et le secteur pétrolier (dans un des grands organismes de recherche du pétrole).

23.- C'est pourquoi notre tâche est fréquemment de préparer pour l'ingénieur étranger un programme spécifique où interviendront d'autres sociétés que la nôtre. Citons, à titre d'exemple, le cas récent d'un ingénieur thaïlandais pour lequel nous avons organisé un stage auquel ont contribué à la fois le B.R.G.M., la société d'engineering SOFREMINES, l'Institut de Recherche de la Sidérurgie, les Houillères de Lorraine et le Centre d'Etude et de Recherches des Charbonnages.

24.- Notre contribution à la formation des cadres techniques des pays neufs ne se borne cependant pas à leur perfectionnement en France. Il est une solution plus efficace encore, parce qu'elle est moins coûteuse et d'un rendement numérique plus élevé : c'est la formation dans le pays même des techniciens et des ingénieurs.

25.- Cette dernière suppose que le pays soit déjà doté d'une sérieuse infrastructure en matière d'enseignement supérieur. Il en va bien ainsi pour certains pays, mais ce sont les moins nombreux. Dans leurs cas, notre rôle est de leur fournir des professeurs pour leurs facultés scientifiques, leurs instituts de géologie et leurs écoles de mines. Nous avons actuellement plusieurs professeurs qui enseignent ainsi à l'étranger pendant tout ou partie de l'année scolaire.

26.- Mais la formation des techniciens subalternes, et en particulier des prospecteurs, est peut-être la plus importante de toutes. Nous l'avons expérimentée en Afrique Noire de deux façons différentes. D'abord par la formation, dans le cadre même de nos travaux, de prospecteurs autochtones progressivement confirmés. C'est ainsi que nous avons procédé à Madagascar et les résultats sont très encourageants. Ensuite, par la création de véritables écoles de prospecteurs. L'une a fonctionné plusieurs années à Dakar avec des promotions de 5 ou 6 élèves ; une autre fonctionne aujourd'hui à Brazzaville.

27.- L'exposé de notre activité dans le domaine de la formation ne serait pas complet si nous ne parlions pas de l'aspect que, faute d'une expression plus claire, j'appellerai l'aspect post-scolaire. Si les ingénieurs français doivent être aidés dans le maintien de leur contact avec l'évolution de la technique, la chose est de toute évidence beaucoup plus nécessaire encore pour l'ingénieur d'un état en développement, qui reparti dans son pays, se trouve souvent coupé de toute relation directe avec la vie même de sa spécialité.

28.- Nous disposons heureusement d'un service d'information technique important et publions en outre de nombreux travaux et études.

29.- Nous nous efforçons ainsi de garder le contact avec nos anciens stagiaires et de leur envoyer les documents qu'ils sollicitent ou que nous jugeons intéressant de leur envoyer.

30.- Voici résumés de façon succincte l'esprit, le cadre et les modalités de notre

action en matière de formation. L'ensemble s'est constitué peu à peu, plus empiriquement qu'en fonction d'une hypothèse de travail pré-établie.

31.- La formation des techniciens français et celle des originaires des pays en développement se pose donc en termes assez différents. Mais pour comprendre les difficultés soulevées par l'équipement en cadres techniques des pays neufs et les moyens propres à y parvenir, il est indispensable de prendre d'abord conscience des problèmes posés par l'évolution de la science et de la technique dans les pays déjà équipés.

32.- Leur examen objectif conduit à une conclusion inquiétante : de même que dans le domaine des niveaux de vie ou de l'équipement économique et industriel, l'évolution accélérée des techniques tend à accroître l'écart entre pays "nantis" et pays "prolétaires" au lieu de le restreindre, dans le domaine de l'équipement en cadres techniques, la loi de spécialisation croissante qui régit notre époque tend aussi à rendre de plus en plus difficile à atteindre ce qui reste pourtant notre but essentiel : permettre aux pays neufs de voler scientifiquement et techniquement de leurs propres ailes.

867 F - Oct.1962 - 1,000

E/CONF.39/A/107
12 Oct.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.4.3.3

Turkey

EVALUATION OF ELECTRIC POWER DEVELOPMENT POLICY IN TURKEY

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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No.1420
A.4.3.3.

EVALUATION OF ELECTRIC POWER DEVELOPMENT POLICY IN TURKEY

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1. INTRODUCTION

The main purpose of this paper is the evaluation of Electric power development policy in Turkey. In order to achieve this aim past and present situation of electric power and organization problems in Turkey have been briefly explained. Tables given in Section 3 clearly show progress made in Turkey in the field of electric power. River basin development planning is very closely related to electric power planning because of main source of electric power production is hydro power. Special importance is given to appraising of hydro power projects. Methods of economic analysis have been briefly explained. Fimally principles of a sound electric power development policy has been discussed.

2 - PAST AND PRESENT STATUS OF ELECTRIC POWER IN TURKEY

The first commercial electric power station in Turkey was put into operation in Tarsus in the year 1902. This was a Hydro-electric power station. After this although many small power stations were installed in various towns and cities, the First World War, War of Independence and following internal troubles affected greatly on the economy of country and so caused to slow down in the development of Electric power in the country until 1930. After 1930 a recovery in the Electric power field was noticed as in the other sectors of economy. But unfortunately this lasted until 1940. During the Second World War and following 2-3 years another great pause was observed. At last some improvement was witnessed in 1948 and especially in 1950 onward. In the period between 1930 and 1948 the power stations were small isolated units consuming valuable fuels such as petroleum and bituminous coal. But in the period from 1948 and especially 1950 onwards large capacity regional power stations were constructed and a tendency to build interconnected networks in the country was observed. Also lignite replaced Bituminous coal and Hydro-electric power was used which is abundant in Turkey. The tables below may explain the case better.

TABLE I - INSTALLED CAPACITY in KWs

Year	Thermal	Hydro	Total
1940	209,946	7,019	216,965
1945	235,962	9,976	245,938
1950	389,896	17,885	407,781
1955	573,515	38,118	611,633
1960	860,528	411,904	1,272,432
1961 (M)	881,200	462,023	1,343,223

TABLE 2 - ELECTRIC POWER PRODUCTION in 1000 KWHs

Year	Thermal	Hydro	Hydro(percentage)	Total
1940	383,004	13,894	3,5	396,898
1945	504,046	23,762	4,5	527,808
1950	759,524	30,100	3,8	789,624
1955	1,490,668	89,150	5,6	1,579,818
1960	1,813,661	1,001,410	35,6	2,811,071
1961 (M)	1,773,500	1,276,500	41,9	3,050,000

TABLE 3 - ELECTRIC POWER CONSUMPTION in 1000 KWHs

Year	Domestic	Industry	Traction	Total
1940	64,727	276,810	7,812	359,349
1945	76,852	365,862	16,294	459,008
1950	152,060	508,821	17,925	678,806
1955	335,021	992,363	19,866	1,347,250
1960	605,705	1,751,464	38,551	2,395,720
1961 (M)	660,000	1,910,000	40,000	2,610,000

TABLE 4 - TOTAL POPULATION, ELECTRIFIED POPULATION PRODUCTION PER CAPITA

Year	Population (1000)	Electrified Population (1000)	Per Capita Production(kWh)
1945	18,790	3,970	28
1950	20,947	4,811	38
1955	24,111	6,540	65
1960	27,810	8,597	101
1961 (M)	28,602	8,950	107

TABLE 5 - POWER TRANSMISSION AND DISTRIBUTION LINES (in Km)

Year	154 kV	66 kV	33 kV	26-15 kV	Total
1940	-	-	14	105.8	119.8
1945	-	-	77	105.8	182.8
1950	-	98.6	77	105.8	281.4
1955	267.4	259.4	328.5	184.8	1042.1
1960	2038.3	851.4	728.4	447.8	4065.9
1961 (M)	2113.3	931.4	743.9	447.8	4236.4

(M) Provisional Figures

Studying these tables one draws the following conclusions:

i. The electric power that was used mainly for lighting now is being used largely in industry.

ii. A great tendency to use Hydro-electric resources has been observed.

iii. Especially in the recent years a development towards a regional interconnected network system was observed. This made it possible for many load centers to draw power from the network which is fed by all the power stations in the region concerned. For this purpose a great deal of overhead lines have been constructed.

iv. In spite of all these rapid developments the fraction of population that makes use of electricity is only about 30 o/o. For the year 1961 the average production of electricity per capita is only 107 kWh.

v. No steps towards electrification of villages have been taken.

3 - ORGANIZATION IN ELECTRIC POWER

The main organization dealing in electric power is the Ministry of Industry. But some other Ministries and certain departments under these Ministries take part also in the Electrification of Turkey. To give a better idea of the type of work done by these establishments the following table is arranged:

TABLE 6 - ORGANIZATIONS IN ELECTRIC POWER

Nature of Work	Ministries						Others		
	Industry			Public Works	Reconst. and Settlements				
	Dept. of Power	Electric Power Resources Survey and Planning Adm. (E.I.E)	Etibank	State Hydraulic Works D.S.I.	Dept. of Planning	Iller-bank	Municipalities	State Economic Enterprises	Private Enterprises
Regulation	++	-	-	- (Hydro only)	-	-	-	- (Own use)	-
Survey	-	++	-	++	++	+	-	-	-
Planning	+	++	+	++	++	+	-	-	-
Design	-	++	++	++	-	++	-	-	-
Const.	-	-	++	++	-	++	++	++	++
Operation	-	-	++	++	-	++	++	++	++

++: Does the work +: Partly does the work -: None

As it is seen from Table 6, 3 ministries and many departments have taken part in electrical works. Some acts of the Parliament imposed certain duties on these establishments. But these acts became in adequate due to rapid development of electrification, therefore, some establishments took parts not exactly in accordance with the law which created a bigger problem leading to difficult situations such as duplications etc. This has many disadvantages as:

i. Misuse of already short technical personnel.
ii. Difficulties in the co-ordination of duties.
iii. The difficulties in establishing the degree of priorities of investments.

On the other hand the tendency of producing electric power from water resources creates the problem of finding the most efficient use of these resources with respect to irrigation, power and flood control.

Due to the fact that the responsibilities of flood control and irrigation and of electric power production fall to different hands, difficulties will no doubt arise in coming years.

In recent years reconnaissance and construction of all power plants and overhead lines excluding water resources, and also operation of Interconnected Network System was considered to be given to a single establishment. Eventually a Bill on this subject has been prepared. But a Bill which does not give any importance to water resources in electric power production may later create greater difficulties in organization problems.

4 - ELECTRIC POWER RESOURCES

The resources used in the production of electric power are divided into two parts:

a) Fossil Fuels
b) Hydro-electric power

In the last ten years a great development of Hydro-electric power resources was noticed with a respective decrease in the use of Fossil fuel resources. The reason of this decrease is due to poorness of Turkey with respect to these Fossil fuel resources. Following paragraphs explain the situation of these resources:

BITUMINOUS COAL: At present there is only one place producing bituminous coal. Many investigations to find richer mines unfortunately failed. Further studies on the present mine show a capacity of 10-13 billion tons of coal. And the present rate of production is 7 million tons per year. This is because the coal layers are thin and immersed in very low levels. Scarcity of bituminous coal makes its price to go above the general price levels of the country. Production of bituminous coal is just enough for manufacturing coke to be used in metal extraction processes. Because of these reasons the use of bituminous coal in production of electrical energy is decreasing. To see this change one only has to notice that in 1950 bituminous coal was used in 55 o/o of plants producing electric power, in 1961 this figure became 12.3 o/o.

LIGNITE : Almost everywhere in Turkey Lignite mines have been found. Some of these mines contain lignite of high calorific value. Unfortunately none of these mines are rich. In all the surveys made up to now one can not find a lignite mine with a total capacity greater than 150 million tons. The total lignite reservation in Turkey's mines comes out to be about 1 billion ton. But it is hoped from Geological studies of Turkey that some quite rich mines can be found. The present rate of production of lignite is about 3 million tons per year. Beside water resources lignite is also taking the place of bituminous coal in electric power production. Transportation of lignite over long distances is less economical than power transmission.

Also building power stations at the mines using lignite makes the mine operation flexible and efficient. Because of this reason while producing 16 o/o of electric power from lignite in 1950, this figure went up to 19 o/o in 1960.

There is another kind of fuel of low calorific value called Washery left coal. It is possible to use this as fuel in power stations. In 1950 11.5 o/o of power production was obtained from such stations. This figure raised to 24 o/o in 1961.

PETROLEUM : In spite of the fact that a search for petroleum is going on in a large scale the results are not very optimistic. The total crude oil production of Turkey is only enough for about 17 o/o percent of Turkey's need. The rest of remaining Turkey's need is being imported as crude oil. Capacity of present refineries in the country is about 5 million tons per year. The heavy fuel oil that is going to be produced in these refineries can be used in electric power production as well as other industrial needs. Soon a Thermo-electric station using 400.000 tons heavy fuel oil per year, will be installed in Istanbul.

HYDRO POWER : In contrast to poorness of Fossil fuel deposits, Turkey has great possibilities in the field of Hydro-electric power production. Possibility of irrigation and flood control make these hydro-electric projects attractive. According to a survey made in 1955 in cooperation with experts from European Economic Commission the gross hydro-electric potential of Turkey was found to be about $536,535 \times 10^6$ kWh per year. Also according to this survey again $105,150 \times 10^6$ kWh/year of this potential can be developed economically. This gives the percentage of economically possible hydro-electric potential to gross hydro-electric potential to be about 20 o/o. This figure in special cases can go up as high as 40 o/o, such as along some parts of Fırat (Euphrates) River which contributes alone to the gross potential an amount of 105,000 10^6 kWh/year.

The distribution of Hydro-electric potential is shown in the table below:

Region	: Gross Hydro-electric Potential in 10^6 kWh
East Black Sea Coast	91,515
Eastern and South-Eastern Anatolia	164,599
Mediterranean Coast	164,242
Other Regions	116,179

The regions where the potential is the densest are Black Sea Coast and some parts of Western Mediterranean Coast. Eastern Black Sea Coast and especially basin of Fırat (Euphrates) River have high densities. If a line drawn across

Turkey from North to South dividing the land into two equal parts. Then 60-65 o/o of Hydro-electric potential falls into the Eastern region. Specially along the Fırat (Euphrates) River it is possible to obtain great blocks of power. For example building three dams on the Fırat (Euphrates) River it is possible to produce 20-21 billion kWh/year of electric power. Also the possibility of irrigation by these dams make these projects rather attractive. However, today 80 o/o of electric power production is consumed in the Western and North-western part of Turkey. But in these parts there is not great hydro-electric potential. It is necessary to develop the hydro-electric potentials in Eastern and Southern Turkey and transmit the power to the Western part of the country. Latest surveys have shown that producing and transmitting power from the Fırat River basin to Western Turkey is very economical. Also the presence of Iron, chromium and copper mines in Eastern Turkey shows the possibility of using this cheap power for heavy industry, in its place of production.

5- ELECTRIC POWER PLANNING

a) Basic Principles in Planning: Planning in the field of electric power depends largely on economic factors. But these are not the only factors in the final decision. Social considerations may play an important role in final decision in some cases.

As it is seen from practice that the factors determining electrical planning can not be estimated closely in a less developed country. For example, neither the effect of supplying cheap and abundant electric power to a region, which uses power for small industry and lighting, can be predicted easily nor can one find the change in demand accurately. Factors effecting the planning of an electric power system may change drastically in newly developing countries. Economics of such countries are not in regular nature and their governments have to take decisions at regular times so electrification is affected.

In Turkey in many cases plants being built with the consideration of sufficiency for 7 or 8 years become inadequate in their second years of operation.

Although electrical investments are heavy burden, the industries employing electricity have investments 3-10 times more. Therefore, in cases of vague determination of necessary power it is more profitable to install electric power supplies beyond the capacity of the present demand.

Also the slogan "Electrical power creates its own market" has been justified with many examples from newly developing countries.

After an explanation of above manner the main principles of Electrification of Turkey may be outlined as follows:

i- Interconnected networks must be substituted instead of isolated power systems.
ii- Needs must be supplied with a margin as large as possible without breaking the harmony in general investments.
iii- In the determination of priority of installations importance should also be given to best possible use of natural resources and other factors like social fundamentals.

b) Relation to National Planning: National Planning in Turkey is a very new subject. The purpose of national planning is to obtain an optimum rate of economical development by developingthe sectors of economy harmoniously. Electrical power has linkage with all economical sectors. Any lack of items in the investment of electric power field will surely have a negative effect on all other sectors of industry. Another difficulty also arises from the impossibility of importing electrical energy in contrast with other field of industry. Therefore, greater care is being given to electrification and the problem of determining the effect of electrical investments on the safety of other industrial fields.

c) Relation to River Basin Development: In Turkey most electrical power production sources will be hydro power in very near future. Today hydro-electric power

production is about 41.9 o/o of total annual electric power production. The Hydro-electric portion in total production will be about 80 o/o in the next ten years. On the other hand irrigation and flood control are very important subjects in Turkey. The utilization of water resources for multiple purposes such as irrigation, flood control and power makes projects attractive in most cases. For example, any single purpose of water power project may not be economical but for multiple purpose use, may become economical.

However, to find the best solution of a water resource project, especially when the number of utilisation purposes increased, becomes very complicated. It becomes necessary to study the case carefully, in detail. Due to this fact Hydro projects are not considered individually but the river basins are generally studied as a whole in order to obtain the harmony among the various purposes. The final selection of hydro power projects for meeting the future power demands is made after the river basin development studies are completed, as it is explained before.

As it can be understood, it is rather difficult to apply this ideal solution to every case.

The chances of knowing the possibility of water sources in every detail and in advance are very few in less developed countries. On the other hand, generally, speaking the fast development rate of the needs of electricity and the other needs narrows the path of the possibility of studying the case in a large scale. In this case it becomes evident to be satisfied with the known possibilities in order to confront the demands on time.

6- APPRAISING OF POWER PROJECTS

There are various methods of appraising the power projects. To select a certain method is generally dependant on the type of the problem. The appraisal of the projects is usually the economical comparison of various alternative solutions which meet the needs. The common methods are:

- Unit price comparison
- Rate of return on investment
- Benefit Cost analysis

On some cases, rate of return on additional investment method is also used.

The interest rate is usually considered 7 o/o in the calculations and the comparison period is the useful life of the installation. The comparison is made on infinite life basis as infinite renewal, where the useful lives are different while comparing the alternative plans. These alternative plans are also compared from the point of labour, taxes, and additional activities created in the other sectors.

a) Forecasting power market requirements : The forecasting power market requirement is one of the most important features while appraising an electrical project. It is a well known factthat the forecasting of power demand in a less industrialized country is more difficult than an industrialized and economically stable country. In case of over forecasting, then more investment is being made on electric sector and this creates an excess capacity. On the other hand under forecasting, results a shortage of electric power to the other economic sectors, which experiences harm to overall economic development. Experiences are proved on electrical systems that a small over invesment is better than an under investment which creates difficulties to the other sectors. Due to all these facts, the electric power requirement forecastings are based on several alternative assumptions especially on the long range planning . It is generally considered whether those plans are flexible on these alternative assumptions and could the necessary changes be made in future years.

The demand forecasting is usually a forecasting of the requirements of the existing customers and the requirements of the possible future potential customers.

The studied region is considered from the stand point of its social and economic conditions and natural resources. Generally, the forecastings are revised every other year.

b) Methods of Establishing Priorities of Alternative Schemes: Establishing the priorities for the alternative plans for interconnected systems are as follows:

i- Forecasting power market requirements
ii- Preparing alternative plans for power production facilities and taking into consideration of meeting demands.
iii- Preparing plans for power transmission for every production plan.

Then investment, operation and maintenance expenditures of every plan will be estimated for a certain period of time. This period is not less than 15 years. Expenditures have been actualized using different rate of interests with this calculation it is possible to find present worth of expenditures of alternative plans for different rate of interests. If a choice made for the rate of interest then one of the plans will have minimum present worth of expenditures using this interest rate.

It is also possible to make comparison of plans taking the differences of expenditures and actualizing the plus or minus differences. The rate of interest used in this process which gives the result almost zero is the rate of return on difference of investment of plans compared. The final choice of investment plan is made not only taking into account above calculations but consideration is also given use of local labor, material, national resources and foreign currency requirements.

c) Benefit Cost Criteria for Medium and Large Hydro Projects: These criteria have been extensively used in the river basin development studies in Turkey. As it is explained before hydro power, irrigation, flood control are closely linked together in many projects. In order to obtain maximum benefits from projects, Benefits and costs for each purpose of the project have been estimated. This estimation has been based on:

i- Irrigation benefits: Additional incomes created from changes of crop pattern and amount of crop due to irrigation taking into consideration of additional costs of irrigation etc.

ii- Flood Control Benefits: This is based mainly on average yearly damage done to the area protected.

iii- Power Benefits: Power benefits are measured using an alternative source of power. It is usually a thermal power project which has same capacity with project power feature. Project yearly firm energy and dependable power are evaluated seperately using equivalent thermal power plant fixed yearly operating cost (Interest, amortization and fixed part of operations and maintenance cost) as the capacity, charges and variable operating cost such as fuel, lubricating oil and variable part of operation and maintenance cost as the energy charges.

If benefits from irrigation and power are increased by the years of operation depending upon increasing demand, future benefits have been actualized using an interest rate about 7 o/o . On the other hand, expenditures of investment and operation of the project is also estimated and actualized.

Now it is possible to calculate ratio of benefits to costs of alternative solutions of the project.

Instead of choosing the project which gives the highest benefits cost ratio but one is selected which gives maximum benefits. This has been determined using incremental benefit cost ratios. When incremental benefit cost ratio is 1 this point gives the maximum benefits.

Benefit cost criteria is also used for single purpose medium and large hydro projects for the determination of coefficient of evaluation of the project. In this case the benefits are not calculated using an equivalent thermal plant but a modern thermal plant in large capacity for the whole network. This way it is possible to find relative values of hydro projects. The ratio of benefits to costs is called "Coefficient of value" of the project. This ratio gives an idea bout priority orders of different projects.

d) Economic Criteria Used for Selecting Transmission Lines: The principle of the method used for selection of transmission lines is to minimize the total of cost of installation and actualized losses over total life of line per Km, variables are being cross section and voltage of the line. The losses of the line are separated as peak power losses and yearly energy losses. Calculation of peak power losses is simple, variables in this calculation are cross section and voltage of the line.

Calculation of energy losses depends not only on these variables but also depends on "loss load factor" which is calculated from load factor and the shape of annual load curve. Some studies made for calculation of "loss load factor" showed that this factor mainly depends on load factor. The effect of the shape of annual load curve is very little. Another difficulty arises when the load of the line changes from one year to another due to increased demands. In this case, calculations made for finding a constant load which gives economical equivalent losses over the life of the line. This equivalent load is called "Effective load". In order to obtain Effective load tables have been prepared based upon different rate of interest and different rate of increase and decrease of the load. The interest rate mainly used in this calculation is 7 o/o,

The peak power losses are evaluated using capacity charges of a thermal power plant and energy losses are evaluated using fuel charges of a modern thermal power plant. These charges are adjusted according to network condition. Both losses are actualized and added to the installation cost of line per Km. However selection of transmission line voltage is done taking into account of transformer stations also.

In the case of isolated hydro stations the losses are not evaluated if water available is more than the demand. The evaluation made after assuming certain date of connection to main system.

7 - MAIN PRINCIPLES OF A SOUND ELECTRIC POWER DEVELOPMENT POLICY FOR TURKEY

a) Basic Principles of a Sound Electric Power Development Policy for Turkey: In spite of great efforts made on electric power production transmission and distribution in last decade, there is much more work to be done. Today in Turkey only 11% of total population makes use of benefits of electric power. The remaining parts which are substantially villages are not electrified at all.

The need of a rapid economic development necessitates a rapid development of electric power. Furthermore Turkey's fossil fuel resources are not rich, in coming years country will probably depends on solely hydro power which is abundant. The experience gained in Turkey for the development of electric power, up to now puts up the basic principles of electric power policy such as:

i- To build countrywide interconnected power system as fast as possible
ii- To supply electric power to the places before the demand forces its use.
iii- To encourage the public for the widespread use of electricity.
iv- To give special importance of development of water resources for power and irrigation.

b) Basic Principles of Reorganization: As it is explained before there are many organizations in electric power field in Turkey. The duties of these organizations are somewhat over lapping.

The reorganization in Electric power is inevitable for the rapid development of electric power. Otherwise the rate of development will be slowed down. The status of natural resources, and existing organizations in electric power create somewhat different reorganization problem from the other countries. Today in Turkey almost all power fields are in the hands of state and municipal organizations. State organizations are mainly interested in power production and transmission, Municipal organizations are mainly interested in distribution. These Municipal organizations are also involved in public transport, water supply and gas works. On the other hand Hydro power in Turkey is very closely linked with irrigation.

The principles of a good reorganization can be put down with a careful study of today's problems. These are:

i- To establish a single organization with responsibilities of power and water planning, construction and Operation. This organization should not deal with the distribution.

ii- Distribution of power should be responsibilities of Municipal and rural organizations.

iii- Municipal organizations involved simultaneously in power, water supply, Public Transport and Gas Works such that a single organization should deal with electric power only.

iv- To increase the capacity of financing of Municipal Bank for the financement of Municipal and rural organizations.

v- The rate policy should be established such that encouragement of the public for the widespread use of electricity and enough margin for auto financing will be realized.

8- CONCLUSIONS

Electric power in Turkey is a promising field of development. Much progress have been done in this field in the last decade. But still more efforts are needed. Turkey's natural resources are very promising especially in water resources which are the heart of agricultural and industrial development.

In order to realize the total electrification all efforts should be unified. To achieve this first priority should be given to reorganizing water and power establishments.

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